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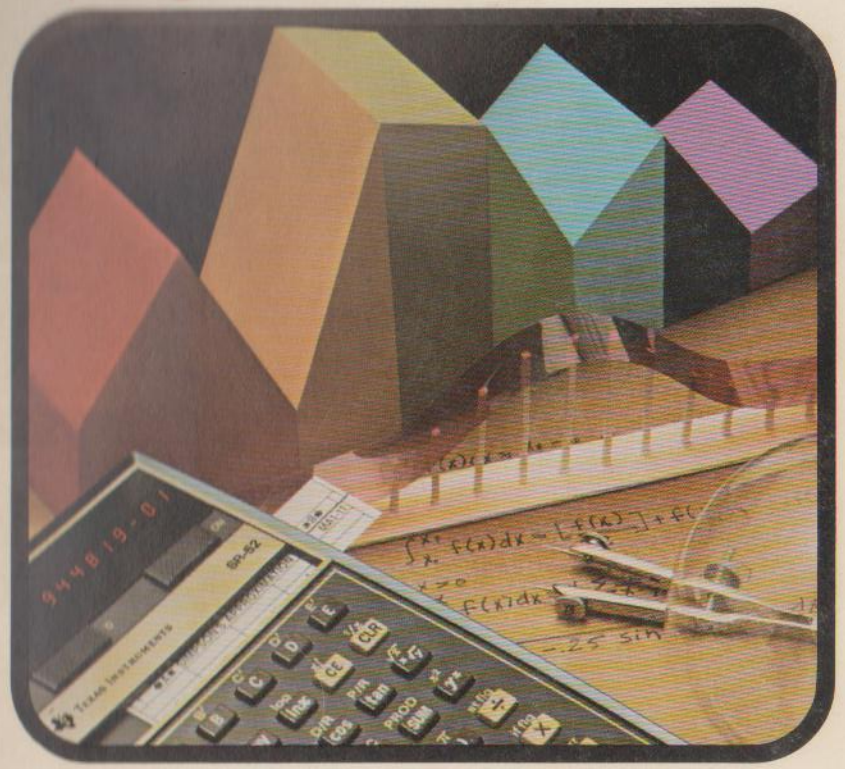
1220803-2

Texas Instruments
programmable calculator



Program Manual MA1
Math Library

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PREFACE

The Math Library includes this program Manual and 35 prerecorded magnetic cards. The programs in this library have been selected because of their common use by mathematicians and other professionals who need rapid solutions to problems involving complex equations, integration, matrices, conversions and general mathematics.

Each program in the Math Library is identified by a program name and number which also appears on each magnetic card. For example, **HYPERBOLIC FUNCTIONS** is the name of the first program and the number is MA1-01... where MA1 identifies the Math Library and -01 identifies the first program in the Math Library. One program is in two parts and has two magnetic cards which must be run one at a time to obtain different but related information. MA1-14-1 identifies the first card of the fourteenth program in the Math Library which is **MATRIX INVERSION AND DETERMINANT (3 X 3).** The second card, MA1-14-2, is part of the same program. Some programs are related by title only and are simply differentiated by a (1) or (2) after the title. The Math Library programs are individually described in this manual. The general description of a program begins on a left-hand page, followed by sample problems, a pictorial of the applicable magnetic card, and complete user instructions. The user instructions list all the necessary steps to perform the specific program. The first step of the user instructions is **enter program** which should be performed according to the procedure on page one of this manual. Each program section also includes a program listing and identification of memory registers and flags used by the program. The program listing provides a backup source to check that the prerecorded program has been correctly read by the calculator.

If you have difficulties in running a program:

1. Be sure that the user instructions have been followed.
2. Refer to Maintenance and Service Information in the Owner's Manual to determine the type of trouble you are having.
3. Write the Consumer Relations Department at:

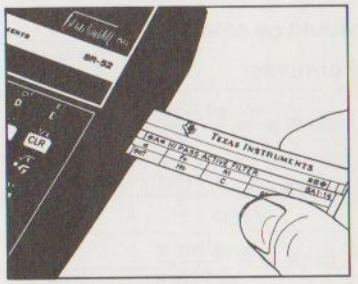
   Texas Instruments Incorporated
   P.O. Box 22283
   Dallas, Texas 75222

   or call Consumer Relations at 800-527-4980 (toll-free within all contiguous United States except Texas) or 800-492-4298 (toll-free within Texas). If outside contiguous United States, call 214-238-5461 (We regret that we cannot accept collect calls at this number).

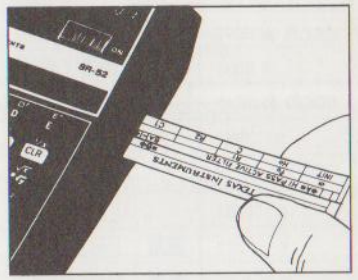
ENTERING A PROGRAM

Use the following procedure each time you need to store the contents of a prerecorded magnetic card in the calculator. Use of this procedure is implied by the *Enter program* instruction in the user instructions of each program.

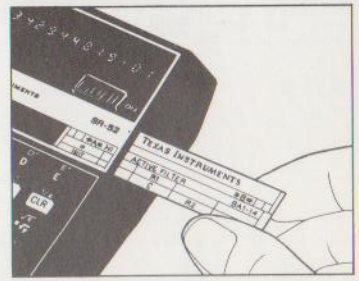
1. Select the proper magnetic card for the program to be run.
2. Read side **A** of the prerecorded card as follows:
   [CLR] [2nd] [read] (Insert card ◂A▪)
   Do not restrict or hold the card after it is caught by the drive motor. The display is blank until the calculator has completed reading side A.



3. Remove the card from the left side of the calculator and read side **B** of the prerecorded card as follows:
   [2nd] [read] (Insert Card ◂B▪)
   The display is blank until the calculator has completed reading side B.



4. Remove card from the left side of the calculator and insert into upper slot such that the A side of the card shows in the window above keys **A** through **E**.



5. If the display flashes immediately following step 2 or 3, repeat the procedure beginning with step 2.

CAUTION: Prerecorded magnetic cards may be damaged or altered if exposed to dust or foreign materials, permanent magnets, or electromagnetic fields (electric motors, power transformers, etc.).

HYPERBOLIC FUNCTIONS

This program calculates all six hyperbolic functions and their inverse functions. It should be noted that these functions may be used within a calculation entered from the keyboard without affecting the natural order of mathematical operations.

Example: $3 + \frac{\sinh \pi}{2} = 8.774369679$

would be entered as [3] [+] [2nd] [π] [A] [÷] [2] [=]

Formulas:

$\sinh x = \frac{e^x - e^{-x}}{2}$ $\quad \sinh^{-1}x = \ln(x + \sqrt{x^2 + 1})$

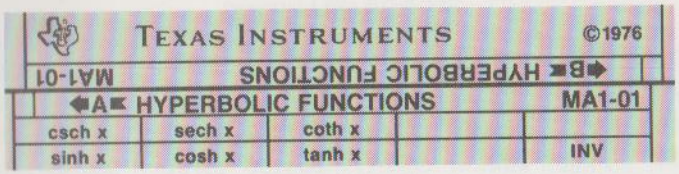
$\cosh x = \frac{e^x + e^{-x}}{2}$ $\quad \cosh^{-1}x = \ln(x + \sqrt{x^2 - 1})$ $\quad (x \geq 1)$

$\tanh x = \frac{\sinh x}{\cosh x}$ $\quad \tanh^{-1}x = \frac{1}{2}\ln\left(\frac{1+x}{1-x}\right)$ $\quad (x^2 < 1)$

$\operatorname{csch} x = \frac{1}{\sinh x}$ $\quad (x \neq 0)$ $\quad \operatorname{csch}^{-1}x = \sinh^{-1}\frac{1}{x}$ $\quad (x \neq 0)$

$\operatorname{sech} x = \frac{1}{\cosh x}$ $\quad \operatorname{sech}^{-1}x = \cosh^{-1}\frac{1}{x}$ $\quad (0 < x \leq 1)$

$\coth x = \frac{1}{\tanh x}$ $\quad (x \neq 0)$ $\quad \coth^{-1}x = \tanh^{-1}\frac{1}{x}$ $\quad (x^2 > 1)$



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
	To compute:					
2	sinh x	x	A			sinh x
3	cosh x	x	B			cosh x
4	tanh x	x	C			tanh x
5	csch x	x	2nd	A'		csch x
6	sech x	x	2nd	B'		sech x
7	coth x	x	2nd	C'		coth x
8	$\sinh^{-1} x$	x	E	A		$\sinh^{-1} x$
9	$\cosh^{-1} x$	x	E	B		$\cosh^{-1} x$
10	$\tanh^{-1} x$	x	E	C		$\tanh^{-1} x$
11	$\operatorname{csch}^{-1} x$	x	E	2nd	A'	$\operatorname{csch}^{-1} x$
12	$\operatorname{sech}^{-1} x$	x	E	2nd	B'	$\operatorname{sech}^{-1} x$
13	$\coth^{-1} x$	x	E	2nd	C'	$\coth^{-1} x$

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 77	*4′	056 50	*st flg	084 01	1
001 16	*A′	029 46	*LBL	057 02	2	085 56	*rtn
002 50	*st flg	030 18	*C′	058 56	*rtn	086 46	*LBL
003 02	2	031 50	*st flg	059 46	*LBL	087 89	*3′
004 46	*LBL	032 02	2	060 10	*E′	088 22	INV
005 11	A	033 46	*LBL	061 22	INV	089 60	*if flg
006 60	*if flg	034 13	C	062 23	Inx	090 02	2
007 01	1	035 60	*if flg	063 42	STO	091 79	*6′
008 87	*1′	036 01	1	064 01	1	092 20	*1/x
009 10	*E′	037 89	*3′	065 09	9	093 46	*LBL
010 02	2	038 10	*E′	066 42	STO	094 79	*6′
011 41	GTO	039 46	*LBL	067 01	1	095 42	STO
012 77	*4′	040 77	*4′	068 08	8	096 01	1
013 46	*LBL	041 22	INV	069 20	*1/x	097 09	9
014 17	*B′	042 49	*PROD	070 44	SUM	098 94	+/−
015 50	*st flg	043 01	1	071 01	1	099 42	STO
016 02	2	044 09	9	072 08	8	100 01	1
017 46	*LBL	045 43	RCL	073 94	+/−	101 08	8
018 12	B	046 01	1	074 44	SUM	102 01	1
019 60	*if flg	047 09	9	075 01	1	103 44	SUM
020 01	1	048 22	INV	076 09	9	104 01	1
021 88	*2′	049 60	*if flg	077 43	RCL	105 09	9
022 10	*E′	050 02	2	078 01	1	106 44	SUM
023 48	*EXC	051 78	*5′	079 08	8	107 01	1
024 01	1	052 20	*1/x	080 56	*rtn	108 08	8
025 09	9	053 46	*LBL	081 46	*LBL	109 48	*EXC
026 02	2	054 78	*5′	082 15	E	110 01	1
027 41	GTO	055 22	INV	083 50	*st flg	111 08	8

*Denotes 2nd function key

REGISTERS

00	05	10	15
01	06	11	16
02	07	12	17
03	08	13	18 Used
04	09	14	19 Used

FLAGS

0	1 Used	2 Used	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 22	INV	140 01	1	168 01	1	196 00	
113 49	*PROD	141 09	9	169 22	INV	197 00	
114 01	1	142 40	*x^2	170 50	*st flg	198 00	
115 09	9	143 42	STO	171 02	2	199 00	
116 93	•	144 01	1	172 56	*rtn	200 00	
117 05	5	145 08	8	173 46	*LBL	201 00	
118 48	*EXC	146 01	1	174 87	*1′	202 00	
119 01	1	147 94	+/−	175 22	INV	203 00	
120 09	9	148 46	*LBL	176 60	*if flg	204 00	
121 23	Inx	149 69	*9′	177 02	2	205 00	
122 49	*PROD	150 44	SUM	178 68	*8′	206 00	
123 01	1	151 01	1	179 20	*1/x	207 00	
124 09	9	152 08	8	180 46	*LBL	208 00	
125 48	*EXC	153 48	*EXC	181 68	*8′	209 00	
126 01	1	154 01	1	182 42	STO	210 00	
127 09	9	155 08	8	183 01	1	211 00	
128 41	GTO	156 30	*$\sqrt{x}$	184 09	9	212 00	
129 50	*st flg	157 44	SUM	185 40	*x^2	213 00	
130 46	*LBL	158 01	1	186 42	STO	214 00	
131 88	*2′	159 09	9	187 01	1	215 00	
132 22	INV	160 48	*EXC	188 08	8	216 00	
133 60	*if flg	161 01	1	189 01	1	217 00	
134 02	2	162 09	9	190 41	GTO	218 00	
135 67	*7′	163 23	Inx	191 69	*9′	219 00	
136 20	*1/x	164 46	*LBL	192 00		220 00	
137 46	*LBL	165 50	*st flg	193 00		221 00	
138 67	*7′	166 22	INV	194 00		222 00	
139 42	STO	167 50	*st flg	195 00		223 00	

*Denotes 2nd function key

SOLUTION OF QUADRATIC EQUATION

Given the coefficients of a quadratic equation, this program computes the real or complex roots using the general solution.

$$ax^2 + bx + c = 0 \qquad (a \neq 0)$$

The roots x_1 and x_2 are

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \qquad x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

If the discriminant $(b^2 - 4ac) \geq 0$, the roots are real. When $(b^2 - 4ac) = 0$, the roots are equal. If $(b^2 - 4ac) < 0$, the roots are complex conjugates and are output in the form:

$$x_1 = rr_1 + i_1 i \qquad x_2 = rr_2 - i_2 i$$

Example: Find the roots of the equation

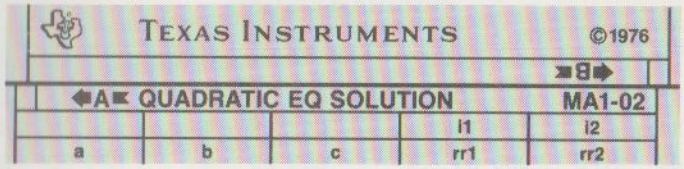
$$1.5x^2 + 3.7x + 2.25 = 0$$

Enter	Press	Display	Comments
1.5	A	1.5	enter a
3.7	B	3.7	enter b
2.25	C	2.25	enter c
	D	−1.088036702	compute rr_1
	2nd D'	0.	compute i part of x_1
	E	−1.378629965	compute rr_2
	2nd E'	0.	compute i part of x_2

Find the roots of the equation

$$x^2 + 2x + 17 = 0$$

Enter	Press	Display	Comments
1	A	1.	enter a
2	B	2.	enter b
17	C	17.	enter c
	D	−1.	compute rr_1
	2nd D'	4.	compute i part of x_1
	E	−1.	compute rr_2
	2nd E'	−4.	compute i part of x_2



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A only)			
2		a	A	a
3		b	B	b
4		c	C	c
5	Compute rr_1		D	rr_1
6	Compute part i of x_1		2nd D'	i_1
7	Compute rr_2		E	rr_2
8	Compute part i of x_2		2nd E'	i_2

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 40	*x^2	056 18	*C′	084 15	E
001 11	A	029 75	−	057 95	=	085 43	RCL
002 42	STO	030 04	4	058 55	÷	086 00	0
003 00	0	031 65	X	059 02	2	087 04	4
004 01	1	032 43	RCL	060 55	÷	088 94	+/−
005 56	*rtn	033 00	0	061 43	RCL	089 60	*if flg
006 46	*LBL	034 01	1	062 00	0	090 00	0
007 12	B	035 65	X	063 01	1	091 78	*5′
008 42	STO	036 43	RCL	064 95	=	092 17	*B′
009 00	0	037 00	0	065 56	*rtn	093 94	+/−
010 02	2	038 03	3	066 46	*LBL	094 18	*C′
011 56	*rtn	039 95	=	067 77	*4′	095 56	*rtn
012 46	*LBL	040 30	*$\sqrt{x}$	068 24	CE	096 46	*LBL
013 13	C	041 42	STO	069 18	*C′	097 10	*E′
014 42	STO	042 00	0	070 42	STO	098 43	RCL
015 00	0	043 04	4	071 00	0	099 00	0
016 03	3	044 70	*if err	072 00	0	100 00	0
017 56	*rtn	045 77	*4′	073 17	*B′	101 94	+/−
018 46	*LBL	046 50	*st flg	074 94	+/−	102 95	=
019 14	D	047 00	0	075 18	*C′	103 56	*rtn
020 00	0	048 46	*LBL	076 56	*rtn	104 46	*LBL
021 42	STO	049 78	*5′	077 46	*LBL	105 17	*B′
022 00	0	050 85	+	078 19	*D′	106 43	RCL
023 00	0	051 17	*B′	079 43	RCL	107 00	0
024 22	INV	052 94	+/−	080 00	0	108 02	2
025 50	*st flg	053 18	*C′	081 00	0	109 56	*rtn
026 00	0	054 56	*rtn	082 56	*rtn	110 00	
027 17	*B′	055 46	*LBL	083 46	*LBL	111 00	

*Denotes 2nd function key

REGISTERS

00 i root	05	10	15
01 a	06	11	16
02 b	07	12	17
03 c	08	13	18
04 Used	09	14	19

FLAGS

0 Used	1	2	3	4

SOLUTION OF CUBIC EQUATION

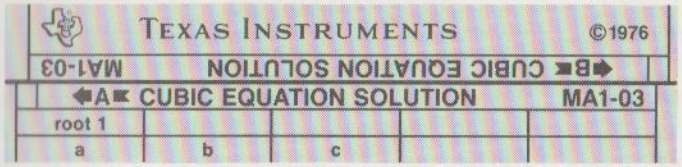
Given the coefficients of a cubic equation in the form:

$$x^3 + ax^2 + bx + c = 0 \qquad (c \neq 0)$$

this program is designed to find a real root of the equation. Synthetic division is then used to reduce the cubic equation to a quadratic equation. The new coefficients are stored so that they are directly accessible by the quadratic equation program MA1-02 that solves for the other two roots (real or imaginary).

Example: $x^3 + 3.1x^2 - 2x + 6.85 = 0$

Enter	Press	Display	Comments
3.1	A	3.1	a
2	+/− B	−2.	b
6.85	C	6.85	c
	2nd A'	−4.021040131	real root 1
Load program MA1-02 (quadratic equation)			
	D	.4605200653	root 2 (real)
	2nd D'	1.221253699	root 2 (imag)
	E	.4605200653	root 3 (real)
	2nd E'	−1.221250699	root 3 (imag)



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Enter a	a	A			a
3	Enter b	b	B			b
4	Enter c	c	C			c
5	Compute root 1 (real root)		2nd	A'		root 1 (real)
6	Enter quadratic equation					
	program MA1-02					
7	Compute root 2		D			real part
			2nd	D'		imaginary part
8	Compute root 3		E			real part
			2nd	E'		imaginary part

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 01	1	056 95	=	084 55	÷
001 11	A	029 40	*x^2	057 55	÷	085 43	RCL
002 42	STO	030 95	=	058 06	6	086 00	0
003 00	0	031 55	÷	059 75	−	087 06	6
004 01	1	032 09	9	060 43	RCL	088 94	+/−
005 56	*rtn	033 95	=	061 00	0	089 95	=
006 46	*LBL	034 42	STO	062 01	1	090 30	*$\sqrt{x}$
007 12	B	035 00	0	063 65	×	091 65	×
008 42	STO	036 04	4	064 40	*x^2	092 43	RCL
009 00	0	037 65	×	065 55	÷	093 00	0
010 02	2	038 40	*x^2	066 02	2	094 05	5
011 56	*rtn	039 95	=	067 07	7	095 80	*if pos
012 46	*LBL	040 42	STO	068 95	=	096 87	*1′
013 13	C	041 00	0	069 42	STO	097 01	1
014 42	STO	042 06	6	070 00	0	098 94	+/−
015 00	0	043 43	RCL	071 05	5	099 41	GTO
016 03	3	044 00	0	072 40	*x^2	100 88	*2′
017 56	*rtn	045 01	1	073 85	+	101 46	*LBL
018 46	*LBL	046 65	×	074 43	RCL	102 87	*1′
019 16	*A′	047 43	RCL	075 00	0	103 01	1
020 03	3	048 00	0	076 06	6	104 46	*LBL
021 65	×	049 02	2	077 95	=	105 88	*2′
022 43	RCL	050 75	−	078 80	*if pos	106 95	=
023 00	0	051 03	3	079 30	*$\sqrt{x}$	107 22	INV
024 02	2	052 65	×	080 43	RCL	108 33	cos
025 75	−	053 43	RCL	081 00	0	109 55	÷
026 43	RCL	054 00	0	082 05	5	110 03	3
027 00	0	055 03	3	083 40	*x^2	111 95	=

*Denotes 2nd function key

REGISTERS

00	05 Used	10	15
01 a	06 Used	11	16
02 b	07	12	17
03 c	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

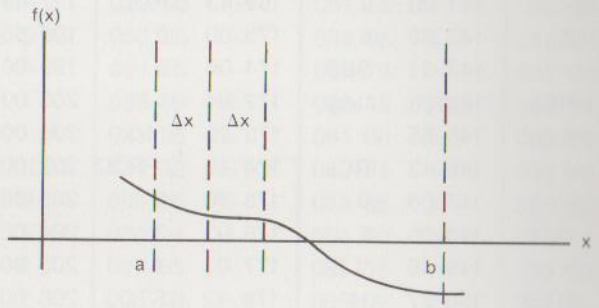
PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 33	cos	140 43	RCL	168 02	2	196 46	*LBL
113 65	×	141 00	0	169 43	RCL	197 89	*3′
114 02	2	142 06	6	170 00	0	198 56	*rtn
115 65	×	143 51	SBR	171 06	6	199 00	
116 43	RCL	144 28	*log	172 94	+/−	200 00	
117 00	0	145 85	+	173 20	*1/x	201 00	
118 04	4	146 43	RCL	174 49	*PROD	202 00	
119 94	+/−	147 00	0	175 00	0	203 00	
120 30	*$\sqrt{x}$	148 05	5	176 03	3	204 00	
121 95	=	149 46	*LBL	177 01	1	205 00	
122 41	GTO	150 77	*4′	178 42	STO	206 00	
123 77	*4′	151 75	−	179 00	0	207 00	
124 46	*LBL	152 43	RCL	180 01	1	208 00	
125 30	*$\sqrt{x}$	153 00	0	181 43	RCL	209 00	
126 30	*$\sqrt{x}$	154 01	1	182 00	0	210 00	
127 42	STO	155 55	÷	183 06	6	211 00	
128 00	0	156 03	3	184 56	*rtn	212 00	
129 06	6	157 95	=	185 46	*LBL	213 00	
130 85	+	158 42	STO	186 28	*log	214 00	
131 43	RCL	159 00	0	187 95	=	215 00	
132 00	0	160 06	6	188 35	*$\sqrt[x]{y}$	216 00	
133 05	5	161 85	+	189 03	3	217 00	
134 51	SBR	162 43	RCL	190 95	=	218 00	
135 28	*log	163 00	0	191 22	INV	219 00	
136 48	*EXC	164 01	1	192 70	*if err	220 00	
137 00	0	165 95	=	193 89	*3′	221 00	
138 05	5	166 48	*EXC	194 24	CE	222 00	
139 75	−	167 00	0	195 94	+/−	223 00	

*Denotes 2nd function key

ZEROS OF FUNCTIONS

This program calculates the roots of a function f(x) using the graphical bisection method.



The function is evaluated over a given interval (a → b) at a sampling increment of Δx. F(x) is entered as a sequence of keystrokes. For example, $f(x) = x^2 + 3x - 7$ would be entered as [STO] 10 [x^2] + 3 [×] [RCL] 10 [−] 7. The values of a and b are supplied by the user whereas Δx, if not specifically input, defaults to b − a. The degree of accuracy, e_{max}, required is also controllable by the user. This maximum error defaults to 10^{-4}, but can be changed by storing the needed value in R_{01} before executing the program.

The method used involves evaluating the function at Δx intervals to see if f(x) changes sign (indicating a root in that interval). The interval is then successively bisected until the necessary accuracy is achieved.

Only one root can be found per Δx interval. If there are no roots in the overall interval (a, b) or all the roots have been found, the display will flash "9.9999 99". If there is more than one root in any Δx interval, the bisection method of finding a root is invalid.

NOTES: 1. For inputting f(x), there is available:
- 56 program memory locations,
- 11 data memory registers (R_{09}-R_{19}), and
- 5 user-definable keys.

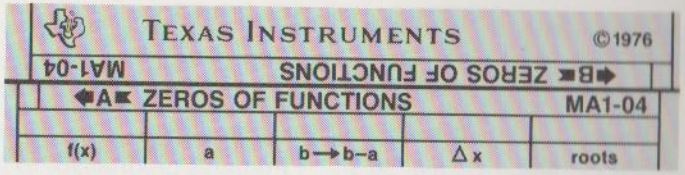
2. In defining the processing interval, a must be entered before b.
3. The calculator is left in fixed point 4 mode after calculations.
4. If calculations result in a flashing display other than "9.9999 99", the number flashed is a root. The flashing was triggered when some undefinable point was encountered while evaluating the function such as f(x) = 1/x evaluated at 0, but the resulting root is correct.
5. If the code for a return (56) is not displayed immediately after entering f(x), a [2nd] [rtn] should be inserted before leaving the learn mode.
6. The maximum error, e_{max}, must be less than b × 10^{-4}.

Example: $f(x) = \sin^2 x - \frac{\tan^2 x}{2}$, evaluate from 0-180°, Δx = 30°, e_{max} defaults to 10^{-4}.

Angle = degrees

Enter	Press	Display	Comments
	[GTO] [A] [LRN]	166 56	Prepares program for f(x)
	[STO] 19	· ·	
	[sin]	· ·	
	[2nd] [x^2]	· ·	
	[−]	· ·	Stores f(x) directly
	[RCL] 19	· ·	into program
	[tan]	· ·	
	[2nd] [x^2]	· ·	
	[÷]	· ·	
2	[=]	180 56	
	[LRN]	0.	Returns to calculate mode
0	[B]	0.	a
180	[C]	180.0000	b
30	[D]	30.0000	Δx
	[E]	0.0000	0° — root 1
	[RUN]	45.0000	45° — root 2
	[RUN]	"135.0000"	135° Flashing — root 3
	[RUN]	" 9.9999 99"	Flashing—shows all roots have been found.

The flashing 135° shows that function is not continuous over the interval just evaluated.



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Key in f(x)	f(x)	LRN			
	Enter other variables					
4	Interval start	a	B			a
5	Interval stop	b	C			b − a
6	Sampling increment	Δx	D			Δx
6	(defaults to b − a)					
7	Maximum error	e_{max}	STO	0	1	e_{max}
	(defaults to 10^{-4})					
8	Execute Program		E			root 1
	(calculate roots)					
9	For additional roots*		RUN			roots 2,3,4,etc.

*NOTE: Flashing "9.9999 99" shows that all the roots in that interval have been found

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 43	RCL	056 75	−	084 03	3
001 87	*1′	029 00	0	057 43	RCL	085 56	*rtn
002 43	RCL	030 08	8	058 00	0	086 46	*LBL
003 00	0	031 42	STO	059 01	1	087 29	*x!
004 07	7	032 00	0	060 95	=	088 43	RCL
005 65	×	033 07	7	061 80	*if pos	089 00	0
006 43	RCL	034 46	*LBL	062 87	*1′	090 03	3
007 00	0	035 89	*3′	063 43	RCL	091 85	+
008 08	8	036 43	RCL	064 00	0	092 43	RCL
009 95	=	037 00	0	065 06	6	093 00	0
010 80	*if pos	038 04	4	066 56	*rtn	094 00	0
011 88	*2′	039 85	+	067 46	*LBL	095 95	=
012 43	RCL	040 43	RCL	068 15	E	096 42	STO
013 00	0	041 00	0	069 43	RCL	097 00	0
014 06	6	042 05	5	070 00	0	098 03	3
015 42	STO	043 95	=	071 03	3	099 42	STO
016 00	0	044 55	÷	072 42	STO	100 00	0
017 05	5	045 02	2	073 00	0	101 05	5
018 41	GTO	046 95	=	074 04	4	102 11	A
019 89	*3′	047 42	STO	075 11	A	103 42	STO
020 46	*LBL	048 00	0	076 42	STO	104 00	0
021 88	*2′	049 06	6	077 00	0	105 08	8
022 43	RCL	050 11	A	078 07	7	106 65	×
023 00	0	051 42	STO	079 22	INV	107 43	RCL
024 06	6	052 00	0	080 90	*if zro	108 00	0
025 42	STO	053 08	8	081 29	*x!	109 07	7
026 00	0	054 40	*x^2	082 43	RCL	110 95	=
027 04	4	055 30	*$\sqrt{x}$	083 00	0	111 22	INV

*Denotes 2nd function key

REGISTERS

00 Δx	05 Used	10	15
01 e_{max}	06 Used	11	16
02 b	07 Used	12	17
03 a(+Δx)	08 Used	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 80	*if pos	140 02	2	168 56	*rtn	196 56	*rtn
113 89	*3′	141 04	4	169 56	*rtn	197 56	*rtn
114 43	RCL	142 94	+/−	170 56	*rtn	198 56	*rtn
115 00	0	143 22	INV	171 56	*rtn	199 56	*rtn
116 03	3	144 28	*log	172 56	*rtn	200 56	*rtn
117 75	−	145 42	STO	173 56	*rtn	201 56	*rtn
118 43	RCL	146 00	0	174 56	*rtn	202 56	*rtn
119 00	0	147 01	1	175 56	*rtn	203 56	*rtn
120 02	2	148 43	RCL	176 56	*rtn	204 56	*rtn
121 95	=	149 00	0	177 56	*rtn	205 56	*rtn
122 22	INV	150 02	2	178 56	*rtn	206 56	*rtn
123 80	*if pos	151 75	−	179 56	*rtn	207 56	*rtn
124 15	E	152 43	RCL	180 56	*rtn	208 56	*rtn
125 25	CLR	153 00	0	181 56	*rtn	209 56	*rtn
126 20	*1/x	154 03	3	182 56	*rtn	210 56	*rtn
127 56	*rtn	155 95	=	183 56	*rtn	211 56	*rtn
128 41	GTO	156 46	*LBL	184 56	*rtn	212 56	*rtn
129 15	E	157 14	D	185 56	*rtn	213 56	*rtn
130 46	*LBL	158 42	STO	186 56	*rtn	214 56	*rtn
131 12	B	159 00	0	187 56	*rtn	215 56	*rtn
132 42	STO	160 00	0	188 56	*rtn	216 56	*rtn
133 00	0	161 57	*fix	189 56	*rtn	217 56	*rtn
134 03	3	162 04	4	190 56	*rtn	218 56	*rtn
135 56	*rtn	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 46	*LBL	164 46	*LBL	192 56	*rtn	220 56	*rtn
137 13	C	165 11	A	193 56	*rtn	221 56	*rtn
138 42	STO	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 00	0	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

SIMULTANEOUS EQUATIONS IN 2 OR 3 UNKNOWNS

Given the coefficients of two simultaneous equations with two unknowns each, the solutions are effected as follows.

$$a_0x + a_1y = a_2$$
$$b_0x + b_1y = b_2$$

$$x = \frac{\begin{vmatrix} a_2 & a_1 \\ b_2 & b_1 \end{vmatrix}}{\begin{vmatrix} a_0 & a_1 \\ b_0 & b_1 \end{vmatrix}} = \frac{a_2b_1 - a_1b_2}{a_0b_1 - a_1b_0}$$

$$y = \frac{\begin{vmatrix} a_0 & a_2 \\ b_0 & b_2 \end{vmatrix}}{\begin{vmatrix} a_0 & a_1 \\ b_0 & b_1 \end{vmatrix}} = \frac{a_0b_2 - a_2b_0}{a_0b_1 - a_1b_0}, \text{ where } a_0b_1 - a_1b_0 \neq 0.$$

For three unknowns:

$$a_0x + a_1y + a_2z = a_3$$
$$b_0x + b_1y + b_2z = b_3$$
$$c_0x + c_1y + c_2z = c_3$$

The program solves for x in the first equation and substitutes the result into the second and third equations. Now only two, two-unknown equations exist and are solved as above.

NOTE: a_0, b_0, and $c_0 \neq 0$.

Example: Solve for x and y in the following two equations:

$5.2x + 3y = 2.56$

$10.9x - 4.3y = -34.87$

Enter	Press	Display	Comments
	2nd CMs	0.	Clear data memories
5.2	2nd A'	5.2	a_0
3	RUN	3.	a_1
2.56	RUN	2.56	a_2
10.9	2nd B'	10.9	b_0
4.3	+/- RUN	−4.3	b_1
34.87	+/- RUN	−34.87	b_2
	D	−1.7	x
	RUN	3.8	y

Example: Solve for x, y, and z.

$.25x - 3.1y - .3z = .675$

$1.25x + .18y + .73z = .901$

$-.8x + 1.1y - 1.6z = -2.074$

$x = .18, y = -.3, z = 1.0$

TEXAS INSTRUMENTS ©1976

MA1-05 SIMULTANEOUS EQUATIONS ➡B➡

⬅A⬅ SIMULTANEOUS EQUATIONS MA1-05

a0,a1,a2,	b0,b1,b2,			
a0,a1,a2,a3	b0,b1,b2,b3	c0,c1,c2,c3	x,y	x,y,z

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Clear Data Memories		2nd CMs	
	Perform Steps 3-4 for			
	2 unknowns OR			
	Perform Steps 5-6 for			
	3 unknowns			
3*	Enter coefficients for	a_0	2nd A'	a_0
	2 unknowns	a_1	RUN	a_1
		a_2	RUN	a_2
		b_1	2nd B'	b_1
		b_2	RUN	b_2
		b_3	RUN	b_3
4	Calculate x and y		D	x
			RUN	y
5*	Enter coefficients for	a_0	A	a_0
	3 unknowns	a_1	RUN	a_1
		a_2	RUN	a_2
		a_3	RUN	a_3
		b_0	B	b_0
		b_1	RUN	b_1
		b_2	RUN	b_2
		b_3	RUN	b_3
		c_0	C	c_0
		c_1	RUN	c_1
		c_2	RUN	c_2
		c_3	RUN	c_3
6	Calculate x, y, and z		E	x
			RUN	y
			RUN	z

*NOTE: To correct input error, return to last user defined key and reenter associated values

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 06	6	056 03	3	084 65	×
001 11	A	029 56	*rtn	057 56	*rtn	085 43	RCL
002 42	STO	030 42	STO	058 46	*LBL	086 01	1
003 00	0	031 00	0	059 14	D	087 01	1
004 00	0	032 07	7	060 10	*E′	088 95	=
005 56	*rtn	033 56	*rtn	061 46	*LBL	089 55	÷
006 42	STO	034 42	STO	062 85	+	090 53	(
007 00	0	035 00	0	063 43	RCL	091 43	RCL
008 01	1	036 08	8	064 00	0	092 00	0
009 56	*rtn	037 56	*rtn	065 09	9	093 06	6
010 42	STO	038 46	*LBL	066 56	*rtn	094 65	×
011 00	0	039 13	C	067 43	RCL	095 43	RCL
012 02	2	040 42	STO	068 00	0	096 01	1
013 56	*rtn	041 01	1	069 04	4	097 02	2
014 42	STO	042 00	0	070 56	*rtn	098 75	−
015 00	0	043 56	*rtn	071 46	*LBL	099 43	RCL
016 03	3	044 46	*LBL	072 10	*E′	100 00	0
017 56	*rtn	045 17	*B′	073 43	RCL	101 07	7
018 46	*LBL	046 42	STO	074 00	0	102 65	×
019 12	B	047 01	1	075 06	6	103 43	RCL
020 42	STO	048 01	1	076 65	×	104 01	1
021 00	0	049 56	*rtn	077 43	RCL	105 01	1
022 05	5	050 42	STO	078 01	1	106 95	=
023 56	*rtn	051 01	1	079 03	3	107 42	STO
024 46	*LBL	052 02	2	080 75	−	108 00	0
025 16	*A′	053 56	*rtn	081 43	RCL	109 04	4
026 42	STO	054 42	STO	082 00	0	110 65	×
027 00	0	055 01	1	083 08	8	111 43	RCL

*Denotes 2nd function key

REGISTERS

00 a_0	05 $-b_0$	10 $-c_0$	15
01 a_1	06 b_1, a_0	11 c_1, b_0	16
02 a_2	07 b_2, a_1	12 c_2, b_1	17
03 a_3	08 b_3, a_2	13 c_3, b_2	18
04 z,y	09 y,x	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00	0	140 02	2	168 42	STO	196 95	=
113 07	7	141 49	*PROD	169 00	0	197 56	*rtn
114 94	+/−	142 00	0	170 09	9	198 41	GTO
115 85	+	143 03	3	171 02	2	199 85	+
116 43	RCL	144 43	RCL	172 44	SUM	200 46	*LBL
117 00	0	145 00	0	173 01	1	201 19	*D′
118 08	8	146 05	5	174 04	4	202 43	RCL
119 95	=	147 42	STO	175 19	*D′	203 00	0
120 55	÷	148 00	0	176 19	*D′	204 04	4
121 43	RCL	149 04	4	177 19	*D′	205 65	×
122 00	0	150 01	1	178 10	*E′	206 36	*IND
123 06	6	151 42	STO	179 65	×	207 43	RCL
124 95	=	152 00	0	180 43	RCL	208 00	0
125 42	STO	153 09	9	181 00	0	209 09	9
126 00	0	154 06	6	182 01	1	210 95	=
127 09	9	155 42	STO	183 94	+/−	211 94	+/−
128 56	*rtn	156 01	1	184 75	−	212 36	*IND
129 46	*LBL	157 04	4	185 43	RCL	213 44	SUM
130 15	E	158 19	*D′	186 00	0	214 01	1
131 43	RCL	159 19	*D′	187 04	4	215 04	4
132 00	0	160 19	*D′	188 65	×	216 01	1
133 00	0	161 43	RCL	189 43	RCL	217 44	SUM
134 20	*1/x	162 01	1	190 00	0	218 00	0
135 49	*PROD	163 00	0	191 02	2	219 09	9
136 00	0	164 42	STO	192 85	+	220 44	SUM
137 01	1	165 00	0	193 43	RCL	221 01	1
138 49	*PROD	166 04	4	194 00	0	222 04	4
139 00	0	167 01	1	195 03	3	223 56	*rtn

*Denotes 2nd function key

LAGRANGE POLYNOMIAL INTERPOLATION

Knowing N pairs of x and f(x) for some unknown function, the following interpolating polynomial can be used to predict new values for f(x):

$$P(x) = \sum_{i=0}^{N} \left[\left(\prod_{\substack{j=0 \\ i \neq j}}^{N} \frac{x - x_i}{x_i - x_j} \right) f(x_i) \right]$$

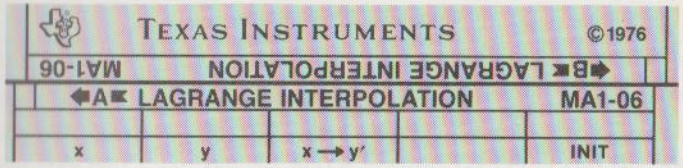
A minimum of three pairs is necessary for accurate results. The x values must be distinct.

Example:

i	0	1	2	3	4
x	1.1	3.2	4.6	6.1	9.5
y	−10	−2.8	3.75	9.9	16.16

Given: x = 5, find y
x = 8.4, find y

Enter	Press	Display	Comments
	E	0.	Initialize program
1.1	A	1.1	x_1
10	+/− B	−10.	y_1
3.2	A	3.2	x_2
2.8	+/− B	−2.8	y_2
4.6	A	4.6	x_3
3.75	B	3.75	y_3
6.1	A	6.1	x_4
9.9	B	9.9	y_4
9.5	A	9.5	x_5
16.16	B	16.16	y_5
5	C	5.54028072	y^1
8.4	C	15.28444892	y^1



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Initialize		E	0.
3	Key in (x,y) pairs	x	A	x
		y	B	y
4	Repeat Step 3 for up to			
	6 pairs			
5	Compute y^1 given a new x	x	C	y^1
6	Step 5 can be repeated as			
	many times as desired			
7	For a new known pair — go			
	to Step 3.			
	For a new case go to Step 2.			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 23	lnx	056 43	RCL	084 36	IND
001 13	C	029 43	RCL	057 00	0	085 43	RCL
002 42	STO	030 00	0	058 03	3	086 00	0
003 00	0	031 02	2	059 95	=	087 01	1
004 06	6	032 75	−	060 49	*PROD	088 95	=
005 25	CLR	033 43	RCL	061 00	0	089 44	SUM
006 42	STO	034 00	0	062 04	4	090 00	0
007 00	0	035 03	3	063 46	*LBL	091 05	5
008 05	5	036 95	=	064 40	*x^2	092 02	2
009 07	7	037 90	*if zro	065 02	2	093 44	SUM
010 42	STO	038 40	*x^2	066 44	SUM	094 00	0
011 00	0	039 43	RCL	067 00	0	095 02	2
012 02	2	040 00	0	068 03	3	096 44	SUM
013 08	8	041 06	6	069 43	RCL	097 00	0
014 42	STO	042 75	−	070 00	0	098 01	1
015 00	0	043 36	*IND	071 03	3	099 43	RCL
016 01	1	044 43	RCL	072 75	−	100 00	0
017 46	*LBL	045 00	0	073 43	RCL	101 02	2
018 29	*x!	046 03	3	074 00	0	102 75	−
019 01	1	047 95	=	075 00	0	103 43	RCL
020 42	STO	048 55	÷	076 95	=	104 00	0
021 00	0	049 53	(	077 22	INV	105 00	0
022 04	4	050 36	*IND	078 80	*if pos	106 95	=
023 07	7	051 43	RCL	079 23	lnx	107 22	INV
024 42	STO	052 00	0	080 43	RCL	108 80	*if pos
025 00	0	053 02	2	081 00	0	109 29	*x!
026 03	3	054 75	−	082 04	4	110 43	RCL
027 46	*LBL	055 36	*IND	083 65	×	111 00	0

*Denotes 2nd function key

REGISTERS

00 Init.	05 Σ	10 x_2	15 y_4
01 y_k	06 x_0	11 y_2	16 x_5
02 x_k	07 y_0	12 x_3	17 y_5
03 x_i	08 x_1	13 y_3	18 x_6
04 π	09 y_1	14 x_4	19 y_6

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 05	5	140 00		168 00		196 00	
113 56	*rtn	141 00		169 00		197 00	
114 46	*LBL	142 00		170 00		198 00	
115 11	A	143 00		171 00		199 00	
116 46	*LBL	144 00		172 00		200 00	
117 12	B	145 00		173 00		201 00	
118 36	*IND	146 00		174 00		202 00	
119 42	STO	147 00		175 00		203 00	
120 00	0	148 00		176 00		204 00	
121 00	0	149 00		177 00		205 00	
122 65	×	150 00		178 00		206 00	
123 01	1	151 00		179 00		207 00	
124 44	SUM	152 00		180 00		208 00	
125 00	0	153 00		181 00		209 00	
126 00	0	154 00		182 00		210 00	
127 95	=	155 00		183 00		211 00	
128 56	*rtn	156 00		184 00		212 00	
129 46	*LBL	157 00		185 00		213 00	
130 15	E	158 00		186 00		214 00	
131 07	7	159 00		187 00		215 00	
132 42	STO	160 00		188 00		216 00	
133 00	0	161 00		189 00		217 00	
134 00	0	162 00		190 00		218 00	
135 25	CLR	163 00		191 00		219 00	
136 56	*rtn	164 00		192 00		220 00	
137 00		165 00		193 00		221 00	
138 00		166 00		194 00		222 00	
139 00		167 00		195 00		223 00	

*Denotes 2nd function key

GAUSSIAN INTEGRATION $\int_{x_0}^{x_f} f(x)dx$

Using the six point Gaussian integration method, this program computes an approximation of the integral:

$$\int_{x_0}^{x_f} f(x)dx \approx \frac{x_f - x_0}{2} \sum_{i=1}^{N} \omega_i f(x_i)$$

where: $x_i = \left(\frac{x_f - x_0}{2}\right) y_i + \frac{x_f - x_0}{2}$

and
$y_1 = -y_2 = .2386191861$
$y_3 = -y_4 = .6612093865$
$y_5 = -y_6 = .9324695142$
$\omega_1 = \omega_2 = .4679139346$
$\omega_3 = \omega_4 = .360761573$
$\omega_5 = \omega_6 = .1713244924$

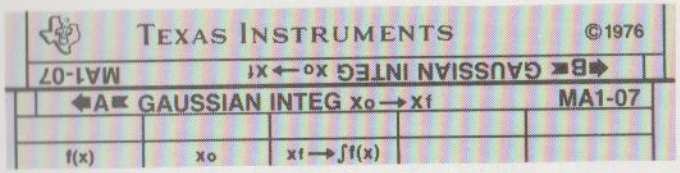
NOTES:
1. f(x) must be defined by a series of keystrokes.
2. There are 46 program locations, 15 data registers (R_{05}-R_{19}), and 5 user defined labels available for f(x) input, x is in the display register when f(x) is being input.
3. Only one level of subroutine can be used while inputting f(x).
4. The code (56) for rtn should be in the display after inputting the last entry of f(x). If not, it should be added.

Reference: *Handbook of Mathematical Functions*, Abramowitz and Stegun, National Bureau of Standards AMS 55, 1966.

Example: Evaluate $\int_0^{\pi/2} \sqrt{1 - .25 \sin^2 x}\, dx$

Angle = radians

Enter	Press	Display	Comments
	GTO A LRN	176 56	Prepares program for f(x)
	sin	. .	
	2nd x^2	. .	Stores f(x) directly
	X	. .	into program
.25	+/− +	. .	
1	= 2nd $\sqrt{x}$	187 56	
	LRN	0.	Returns to calculate mode
0	B	0.	x_0
	2nd π ÷	3.141592654	π
2	=	1.570796327	$\pi/2$
	C	1.467462212	$\int f(x)$



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter f(x)	f(x)	LRN			
4	Enter x_o	x_o	B			x_o
5	Enter x_f and execute program	x_f	C			$\int f(x)$

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 01	1	056 46	*LBL	084 53	(
001 13	C	029 03	3	057 19	*D′	085 43	RCL
002 42	STO	030 09	9	058 43	RCL	086 00	0
003 00	0	031 03	3	059 00	0	087 01	1
004 01	1	032 04	4	060 01	1	088 75	−
005 50	*st flg	033 06	6	061 75	−	089 43	RCL
006 00	0	034 46	*LBL	062 43	RCL	090 00	0
007 50	*st flg	035 10	*E′	063 00	0	091 00	0
008 01	1	036 42	STO	064 00	0	092 54	)
009 93	•	037 00	0	065 95	=	093 55	÷
010 02	2	038 03	3	066 65	×	094 02	2
011 03	3	039 19	*D′	067 43	RCL	095 65	×
012 08	8	040 01	1	068 00	0	096 43	RCL
013 06	6	041 94	+/−	069 02	2	097 00	0
014 01	1	042 49	*PROD	070 85	+	098 03	3
015 09	9	043 00	0	071 43	RCL	099 95	=
016 01	1	044 02	2	072 00	0	100 44	SUM
017 08	8	045 19	*D′	073 01	1	101 00	0
018 06	6	046 60	*if flg	074 85	+	102 04	4
019 01	1	047 00	0	075 43	RCL	103 56	*rtn
020 42	STO	048 87	*1′	076 00	0	104 46	*LBL
021 00	0	049 60	*if flg	077 00	0	105 87	*1′
022 02	2	050 01	1	078 95	=	106 22	INV
023 93	•	051 88	*2′	079 55	÷	107 50	*st flg
024 04	4	052 43	RCL	080 02	2	108 00	0
025 06	6	053 00	0	081 95	=	109 93	•
026 07	7	054 04	4	082 11	A	110 06	6
027 09	9	055 56	*rtn	083 65	×	111 06	6

*Denotes 2nd function key

REGISTERS

00 x_o	05	10	15
01 x_f	06	11	16
02 y_i	07	12	17
03 ω_i	08	13	18
04 $\int f(x)$	09	14	19

FLAGS

0 Used	1 Used	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 01	1	140 02	2	168 12	B	196 56	*rtn
113 02	2	141 04	4	169 47	*CMs	197 56	*rtn
114 00	0	142 06	6	170 42	STO	198 56	*rtn
115 09	9	143 09	9	171 00	0	199 56	*rtn
116 03	3	144 05	5	172 00	0	200 56	*rtn
117 08	8	145 01	1	173 56	*rtn	201 56	*rtn
118 06	6	146 04	4	174 46	*LBL	202 56	*rtn
119 05	5	147 02	2	175 11	A	203 56	*rtn
120 42	STO	148 42	STO	176 56	*rtn	204 56	*rtn
121 00	0	149 00	0	177 56	*rtn	205 56	*rtn
122 02	2	150 02	2	178 56	*rtn	206 56	*rtn
123 93	•	151 93	•	179 56	*rtn	207 56	*rtn
124 03	3	152 01	1	180 56	*rtn	208 56	*rtn
125 06	6	153 07	7	181 56	*rtn	209 56	*rtn
126 00	0	154 01	1	182 56	*rtn	210 56	*rtn
127 07	7	155 03	3	183 56	*rtn	211 56	*rtn
128 06	6	156 02	2	184 56	*rtn	212 56	*rtn
129 01	1	157 04	4	185 56	*rtn	213 56	*rtn
130 05	5	158 04	4	186 56	*rtn	214 56	*rtn
131 07	7	159 09	9	187 56	*rtn	215 56	*rtn
132 03	3	160 02	2	188 56	*rtn	216 56	*rtn
133 41	GTO	161 04	4	189 56	*rtn	217 56	*rtn
134 10	*E′	162 22	INV	190 56	*rtn	218 56	*rtn
135 46	*LBL	163 50	*st flg	191 56	*rtn	219 56	*rtn
136 88	*2′	164 01	1	192 56	*rtn	220 56	*rtn
137 93	•	165 41	GTO	193 56	*rtn	221 56	*rtn
138 09	9	166 10	*E′	194 56	*rtn	222 56	*rtn
139 03	3	167 46	*LBL	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

GAUSSIAN INTEGRATION $\int_{x_0}^{\infty} f(x)dx$

Using the six point Gaussian Integration method, this program computes an approximation of the integral:

$$\int_{x_0}^{\infty} f(x)dx \approx 1/2 \sum_{i=1}^{6} \frac{4_{\omega i}}{(1 + y_i)^2} f(x_i)$$

where: $x_i = \left(\frac{2}{1 + y_i}\right) + x_0 - 1$

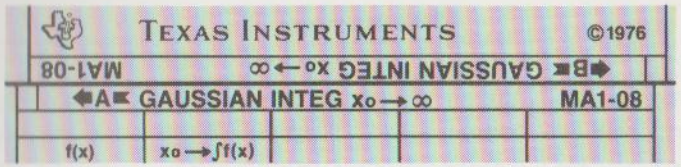
and $y_1 = -y_2 = .2386191861$
$y_3 = -y_4 = .6612093865$
$y_5 = -y_6 = .9324695142$
$\omega_1 = \omega_2 = .4679139346$
$\omega_3 = \omega_4 = .360761573$
$\omega_5 = \omega_6 = .1713244924$

NOTES: 1. f(x) must be defined by a sequence of keystrokes.
2. There are 60 program locations, 15 data registers (R_5-R_{19}), and 5 user defined labels available for f(x) input, x is assumed to be in the display register when inputting f(x).
3. Only one level of subroutine can be used when inputting f(x)
4. The code (56) for a return should be in the display after inputting the last entry for f(x). If not, it should be added.

Reference: *Mathematical Handbook for Science and Engineers*, Korn and Korn, McGraw-Hill, 1968.

Example: Solve $f(x) = \int_{2}^{\infty} \frac{6}{x^7} dx$

Enter	Press	Display	Comments
	GTO A LRN	161 56	Prepares program for f(x)
	y^x	. .	
7	÷	. .	Stores f(x) directly
6	= 2nd 1/x	167 56	into program
	LRN	0.	Returns to calculate mode
2	B	.0156250956	Enter x_0, display ∫ f(x)



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter f(x)	f(x)	LRN			
4	Enter x_0 and execute program	x_0	B			∫ f(x)

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 09	9	056 56	*rtn	084 02	2
001 12	B	029 01	1	057 46	*LBL	085 54	)
002 47	*CMs	030 03	3	058 19	*D′	086 40	*x^2
003 42	STO	031 09	9	059 02	2	087 65	×
004 00	0	032 03	3	060 55	÷	088 43	RCL
005 00	0	033 04	4	061 53	(	089 00	0
006 50	*st flg	034 06	6	062 01	1	090 03	3
007 00	0	035 46	*LBL	063 85	+	091 95	=
008 50	*st flg	036 10	*E′	064 43	RCL	092 44	SUM
009 01	1	037 42	STO	065 00	0	093 00	0
010 93	•	038 00	0	066 02	2	094 04	4
011 02	2	039 03	3	067 54	)	095 56	*rtn
012 03	3	040 19	*D′	068 85	+	096 46	*LBL
013 08	8	041 01	1	069 43	RCL	097 87	*1′
014 06	6	042 94	+/−	070 00	0	098 22	INV
015 01	1	043 49	*PROD	071 00	0	099 50	*st flg
016 09	9	044 00	0	072 75	−	100 00	0
017 01	1	045 02	2	073 01	1	101 93	•
018 08	8	046 19	*D′	074 95	=	102 06	6
019 06	6	047 60	*if flg	075 11	A	103 06	6
020 01	1	048 00	0	076 65	×	104 01	1
021 42	STO	049 87	*1′	077 02	2	105 02	2
022 00	0	050 60	*if flg	078 55	÷	106 00	0
023 02	2	051 01	1	079 53	(	107 09	9
024 93	•	052 88	*2′	080 01	1	108 03	3
025 04	4	053 43	RCL	081 85	+	109 08	8
026 06	6	054 00	0	082 43	RCL	110 06	6
027 07	7	055 04	4	083 00	0	111 05	5

*Denotes 2nd function key

REGISTERS

00 x_o	05	10	15
01	06	11	16
02 y_i	07	12	17
03 ω_i	08	13	18
04 $\int f(x)$	09	14	19

FLAGS

0 Used	1 Used	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 42	STO	140 42	STO	168 56	*rtn	196 56	*rtn
113 00	0	141 00	0	169 56	*rtn	197 56	*rtn
114 02	2	142 02	2	170 56	*rtn	198 56	*rtn
115 93	•	143 93	•	171 56	*rtn	199 56	*rtn
116 03	3	144 01	1	172 56	*rtn	200 56	*rtn
117 06	6	145 07	7	173 56	*rtn	201 56	*rtn
118 00	0	146 01	1	174 56	*rtn	202 56	*rtn
119 07	7	147 03	3	175 56	*rtn	203 56	*rtn
120 06	6	148 02	2	176 56	*rtn	204 56	*rtn
121 01	1	149 04	4	177 56	*rtn	205 56	*rtn
122 05	5	150 04	4	178 56	*rtn	206 56	*rtn
123 07	7	151 09	9	179 56	*rtn	207 56	*rtn
124 03	3	152 02	2	180 56	*rtn	208 56	*rtn
125 41	GTO	153 04	4	181 56	*rtn	209 56	*rtn
126 10	*E′	154 22	INV	182 56	*rtn	210 56	*rtn
127 46	*LBL	155 50	*st flg	183 56	*rtn	211 56	*rtn
128 88	*2′	156 01	1	184 56	*rtn	212 56	*rtn
129 93	•	157 41	GTO	185 56	*rtn	213 56	*rtn
130 09	9	158 10	*E′	186 56	*rtn	214 56	*rtn
131 03	3	159 46	*LBL	187 56	*rtn	215 56	*rtn
132 02	2	160 11	A	188 56	*rtn	216 56	*rtn
133 04	4	161 56	*rtn	189 56	*rtn	217 56	*rtn
134 06	6	162 56	*rtn	190 56	*rtn	218 56	*rtn
135 09	9	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 05	5	164 56	*rtn	192 56	*rtn	220 56	*rtn
137 01	1	165 56	*rtn	193 56	*rtn	221 56	*rtn
138 04	4	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 02	2	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

TRAPEZOIDAL INTEGRATION, GIVEN f(x)

This program will calculate the trapezoidal approximation of $\int_{x_0}^{x_f} f(x)\,dx$.

$$\int_{x_0}^{x_f} f(x)dx \approx [\,1/2f(x_0) + f(x_1) + \ldots + f(x_{n-1}) + 1/2f(x_n)\,]\,\Delta x$$

where: $\Delta x > 0$.

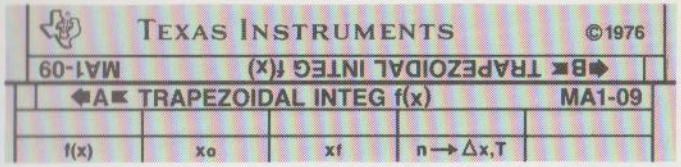
NOTES:
1. f(x) must be defined by a sequence of keystrokes.
2. There are 138 program locations, 14 data registers (R_{06}-R_{19}), and 6 user defined labels available for f(x) input, x is assumed to be in the display register when inputting f(x).
3. f(x) input must not end in a subroutine if one is used to define f(x).
4. Only one level of subroutine can be used for inputting f(x).
5. The code (56) for a return should be in the display after inputting the last entry for f(x). If not, it should be added.
6. 'n' must be an integer; if a non-integer is entered, only the integer part of the entry is used.

Reference: *Computer Methods for Science and Engineering*, Robert L. LaFara, Hayden Book Company, 1973.

Example: Solve $f(x) = \int_{.1}^{1.0} \frac{\sin x\,dx}{x}$, x in radians, n = 9 intervals

Angle = radians

Enter	Press	Display	Comments
	GTO A LRN	87 56	Prepares program for f(x)
	STO 19	· ·	
	sin	· ·	
	÷	· ·	Stores f(x) directly into program
	RCL 19	· ·	
	=	96 56	
	LRN	0.	Returns to calculate mode
.1	B	0.1	x_0
1	C	1.	x_f
9	D	0.1	Enter n, display Δx
	RUN	.8459153635	$\int f(x)$



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter f(x)	f(x)	LRN			
4	Enter x_o	x_o	B			x_o
5	Enter x_f	x_f	C			x_f
6	Enter number of intervals	n	D			Δx
7	Compute T		RUN			T

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 53	(	056 32	sin	084 56	*rtn
001 12	B	029 43	RCL	057 44	SUM	085 46	*LBL
002 42	STO	030 00	0	058 00	0	086 11	A
003 00	0	031 02	2	059 05	5	087 56	*rtn
004 01	1	032 75	−	060 43	RCL	088 56	*rtn
005 56	*rtn	033 43	RCL	061 00	0	089 56	*rtn
006 46	*LBL	034 00	0	062 03	3	090 56	*rtn
007 13	C	035 01	1	063 44	SUM	091 56	*rtn
008 42	STO	036 42	STO	064 00	0	092 56	*rtn
009 00	0	037 00	0	065 04	4	093 56	*rtn
010 02	2	038 04	4	066 43	RCL	094 56	*rtn
011 56	*rtn	039 95	=	067 00	0	095 56	*rtn
012 46	*LBL	040 42	STO	068 04	4	096 56	*rtn
013 14	D	041 00	0	069 11	A	097 56	*rtn
014 22	INV	042 03	3	070 58	*dsz	098 56	*rtn
015 52	EE	043 81	HLT	071 32	sin	099 56	*rtn
016 57	*fix	044 00	0	072 55	÷	100 56	*rtn
017 00	0	045 42	STO	073 02	2	101 56	*rtn
018 52	EE	046 00	0	074 85	+	102 56	*rtn
019 22	INV	047 05	5	075 43	RCL	103 56	*rtn
020 52	EE	048 43	RCL	076 00	0	104 56	*rtn
021 57	*fix	049 00	0	077 05	5	105 56	*rtn
022 09	9	050 04	4	078 95	=	106 56	*rtn
023 42	STO	051 11	A	079 65	×	107 56	*rtn
024 00	0	052 55	÷	080 43	RCL	108 56	*rtn
025 00	0	053 02	2	081 00	0	109 56	*rtn
026 20	*1/x	054 95	=	082 03	3	110 56	*rtn
027 65	×	055 46	*LBL	083 95	=	111 56	*rtn

*Denotes 2nd function key

REGISTERS

00 n	05 SUM	10	15
01 x_o	06	11	16
02 x_f	07	12	17
03 Δx	08	13	18
04 x′	09	14	19

FLAGS

0	1	2	3	4

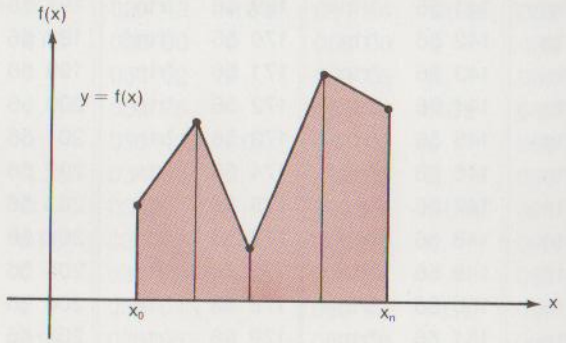
PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 56	*rtn	140 56	*rtn	168 56	*rtn	196 56	*rtn
113 56	*rtn	141 56	*rtn	169 56	*rtn	197 56	*rtn
114 56	*rtn	142 56	*rtn	170 56	*rtn	198 56	*rtn
115 56	*rtn	143 56	*rtn	171 56	*rtn	199 56	*rtn
116 56	*rtn	144 56	*rtn	172 56	*rtn	200 56	*rtn
117 56	*rtn	145 56	*rtn	173 56	*rtn	201 56	*rtn
118 56	*rtn	146 56	*rtn	174 56	*rtn	202 56	*rtn
119 56	*rtn	147 56	*rtn	175 56	*rtn	203 56	*rtn
120 56	*rtn	148 56	*rtn	176 56	*rtn	204 56	*rtn
121 56	*rtn	149 56	*rtn	177 56	*rtn	205 56	*rtn
122 56	*rtn	150 56	*rtn	178 56	*rtn	206 56	*rtn
123 56	*rtn	151 56	*rtn	179 56	*rtn	207 56	*rtn
124 56	*rtn	152 56	*rtn	180 56	*rtn	208 56	*rtn
125 56	*rtn	153 56	*rtn	181 56	*rtn	209 56	*rtn
126 56	*rtn	154 56	*rtn	182 56	*rtn	210 56	*rtn
127 56	*rtn	155 56	*rtn	183 56	*rtn	211 56	*rtn
128 56	*rtn	156 56	*rtn	184 56	*rtn	212 56	*rtn
129 56	*rtn	157 56	*rtn	185 56	*rtn	213 56	*rtn
130 56	*rtn	158 56	*rtn	186 56	*rtn	214 56	*rtn
131 56	*rtn	159 56	*rtn	187 56	*rtn	215 56	*rtn
132 56	*rtn	160 56	*rtn	188 56	*rtn	216 56	*rtn
133 56	*rtn	161 56	*rtn	189 56	*rtn	217 56	*rtn
134 56	*rtn	162 56	*rtn	190 56	*rtn	218 56	*rtn
135 56	*rtn	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 56	*rtn	164 56	*rtn	192 56	*rtn	220 56	*rtn
137 56	*rtn	165 56	*rtn	193 56	*rtn	221 56	*rtn
138 56	*rtn	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 56	*rtn	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

TRAPEZOIDAL INTEGRATION, GIVEN x_n, $f(x_n)$

This program computes a trapezoidal approximation of the area under a piecewise linear curve with known points (x_n, $f(x_n)$).

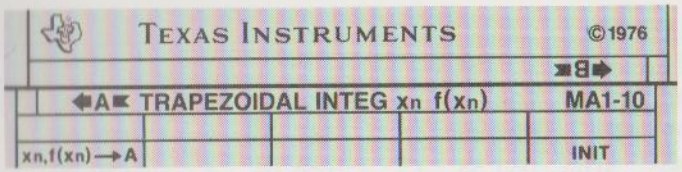


The cumulative area beneath the line between points x_0 and x_n will be the result.

Example: Compute the area beneath the graph described by the following points:

x	3.0	3.2	3.4	4.0	4.1	4.3	4.8	5.0
y	4	6	5	4	4	5	6	7

Enter	Press	Display	Comments
	E	0.	Initialize
3	A	3.	x_0
4	RUN	0.	First point
3.2	A	3.2	x_1
6	RUN	1.	area ($x_0 \rightarrow x_1$)
3.4	A	3.4	x_2
5	RUN	2.1	area ($x_0 \rightarrow x_2$)
4	A	4.	x_3
4	RUN	4.8	area ($x_0 \rightarrow x_3$)
4.1	A	4.1	x_4
4	RUN	5.2	area ($x_0 \rightarrow x_4$)
4.3	A	4.3	x_5
5	RUN	6.1	area ($x_0 \rightarrow x_5$)
4.8	A	4.8	x_6
6	RUN	8.85	area ($x_0 \rightarrow x_6$)
5	A	5.	x_7
7	RUN	10.15	area ($x_0 \rightarrow x_7$)



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A only)			
2	Initialize		E	
3	Enter x_n	x_n	A	x_n
4	Enter $f(x_n)$	$f(x_n)$	RUN	Cumulative Area
	Submit as many pairs of			
	x_n and $f(x_n)$ (Steps 3,4)			
	as necessary			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 95	=	056 43	RCL	084 00	
001 15	E	029 65	×	057 00	0	085 00	
002 50	*st flg	030 53	(	058 04	4	086 00	
003 00	0	031 43	RCL	059 56	*rtn	087 00	
004 00	0	032 00	0	060 46	*LBL	088 00	
005 42	STO	033 01	1	061 52	EE	089 00	
006 00	0	034 75	−	062 22	INV	090 00	
007 04	4	035 43	RCL	063 50	*st flg	091 00	
008 56	*rtn	036 00	0	064 00	0	092 00	
009 46	*LBL	037 00	0	065 41	GTO	093 00	
010 11	A	038 95	=	066 24	CE	094 00	
011 42	STO	039 44	SUM	067 00		095 00	
012 00	0	040 00	0	068 00		096 00	
013 01	1	041 04	4	069 00		097 00	
014 56	*rtn	042 46	*LBL	070 00		098 00	
015 42	STO	043 24	CE	071 00		099 00	
016 00	0	044 43	RCL	072 00		100 00	
017 03	3	045 00	0	073 00		101 00	
018 60	*if flg	046 01	1	074 00		102 00	
019 00	0	047 42	STO	075 00		103 00	
020 52	EE	048 00	0	076 00		104 00	
021 85	+	049 00	0	077 00		105 00	
022 43	RCL	050 43	RCL	078 00		106 00	
023 00	0	051 00	0	079 00		107 00	
024 02	2	052 03	3	080 00		108 00	
025 95	=	053 42	STO	081 00		109 00	
026 55	÷	054 00	0	082 00		110 00	
027 02	2	055 02	2	083 00		111 00	

*Denotes 2nd function key

REGISTERS

00 x_{n-1}	05	10	15
01 x_n	06	11	16
02 y_{n-1}	07	12	17
03 y_n	08	13	18
04 Area	09	14	19

FLAGS

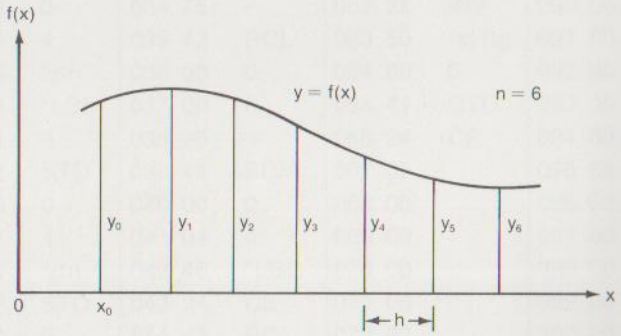
0 Used	1	2	3	4

SIMPSON'S APPROXIMATION

This program uses Simpson's Rule to approximate the area A_s under the curve f(x) over the interval (x_0, x_f).

$$\int_{x_0}^{x_f} f(x)\,dx \approx A_s = \frac{h}{3}(y_0 + 4y_1 + 2y_2 + 4y_3 + 2y_4 + \ldots + 2y_{n-2} + 4y_{n-1} + y_n)$$

where: $h = \frac{x_f - x_0}{n}$, $x_f > x_0$, n = number of intervals, n = 2, 4, 6...

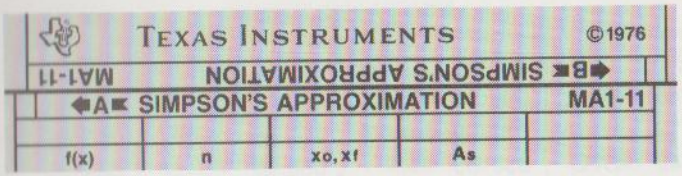


NOTES: 1. f(x) must be defined by a series of keystrokes.
2. There are 68 program locations, 15 data registers ($R_{05} - R_{19}$) and 5 user defined labels available for f(x) input, assume x is in the display register when f(x) is being input.
3. Only one level of subroutine can be used while inputting f(x). f(x) input must not end in a subroutine if one is used to define f(x).
4. The code (56) for a return should be in the display after inputting the last entry of f(x). If not, it should be added.
5. Error conditions: $n \neq 2, 4, 6\ldots$

Reference: *Calculus and Analytic Geometry*, George B. Thomas, Jr., Addison-Wesley, 1961.

Example: Evaluate $f(x) = x^2$, for n = 10, $x_0 = 0$, and $x_f = 5$

Enter	Press	Display	Comments
	GTO A LRN	156 56	Prepares program for f(x)
	2nd x^2	157 56	Stores f(x) into program
	LRN	0.	Returns to calculate mode
10	B	10.	n
0	C	0.	x_0
5	RUN	5.	x_f
	D	41.66666667	A_s



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter f(x)	f(x)	LRN			
4	Enter n	n	B			n
5	Enter x_o	x_o	C			x_o
6	Enter x_f	x_f	RUN			x_f
7	Calculate A_s		D			A_s

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 57	*fix	056 00	0	084 46	*LBL
001 12	B	029 09	9	057 56	*rtn	085 65	×
002 42	STO	030 65	×	058 42	STO	086 15	E
003 00	0	031 02	2	059 00	0	087 43	RCL
004 03	3	032 75	−	060 02	2	088 00	0
005 75	−	033 43	RCL	061 75	−	089 00	0
006 02	2	034 00	0	062 43	RCL	090 11	A
007 95	=	035 03	3	063 00	0	091 65	×
008 22	INV	036 95	=	064 00	0	092 04	4
009 80	*if pos	037 22	INV	065 95	=	093 95	=
010 87	*1′	038 90	*if zro	066 55	÷	094 44	SUM
011 43	RCL	039 87	*1′	067 43	RCL	095 00	0
012 00	0	040 43	RCL	068 00	0	096 04	4
013 03	3	041 00	0	069 03	3	097 15	E
014 55	÷	042 03	3	070 95	=	098 43	RCL
015 02	2	043 56	*rtn	071 48	*EXC	099 00	0
016 95	=	044 46	*LBL	072 00	0	100 00	0
017 22	INV	045 87	*1′	073 02	2	101 11	A
018 52	EE	046 00	0	074 56	*rtn	102 42	STO
019 75	−	047 20	*1/x	075 46	*LBL	103 00	0
020 93	•	048 43	RCL	076 14	D	104 01	1
021 05	5	049 00	0	077 43	RCL	105 43	RCL
022 95	=	050 03	3	078 00	0	106 00	0
023 57	*fix	051 56	*rtn	079 00	0	107 03	3
024 00	0	052 46	*LBL	080 11	A	108 75	−
025 52	EE	053 13	C	081 42	STO	109 02	2
026 22	INV	054 42	STO	082 00	0	110 95	=
027 52	EE	055 00	0	083 04	4	111 42	STO

*Denotes 2nd function key

REGISTERS

00 x_n	05	10	15
01 Used	06	11	16
02 Used	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00	0	140 02	2	168 56	*rtn	196 56	*rtn
113 03	3	141 55	÷	169 56	*rtn	197 56	*rtn
114 90	*if zro	142 03	3	170 56	*rtn	198 56	*rtn
115 32	sin	143 95	=	171 56	*rtn	199 56	*rtn
116 43	RCL	144 56	*rtn	172 56	*rtn	200 56	*rtn
117 00	0	145 46	*LBL	173 56	*rtn	201 56	*rtn
118 01	1	146 15	E	174 56	*rtn	202 56	*rtn
119 65	×	147 43	RCL	175 56	*rtn	203 56	*rtn
120 02	2	148 00	0	176 56	*rtn	204 56	*rtn
121 95	=	149 02	2	177 56	*rtn	205 56	*rtn
122 44	SUM	150 44	SUM	178 56	*rtn	206 56	*rtn
123 00	0	151 00	0	179 56	*rtn	207 56	*rtn
124 04	4	152 00	0	180 56	*rtn	208 56	*rtn
125 41	GTO	153 56	*rtn	181 56	*rtn	209 56	*rtn
126 65	×	154 46	*LBL	182 56	*rtn	210 56	*rtn
127 46	*LBL	155 11	A	183 56	*rtn	211 56	*rtn
128 32	sin	156 56	*rtn	184 56	*rtn	212 56	*rtn
129 43	RCL	157 56	*rtn	185 56	*rtn	213 56	*rtn
130 00	0	158 56	*rtn	186 56	*rtn	214 56	*rtn
131 01	1	159 56	*rtn	187 56	*rtn	215 56	*rtn
132 85	+	160 56	*rtn	188 56	*rtn	216 56	*rtn
133 43	RCL	161 56	*rtn	189 56	*rtn	217 56	*rtn
134 00	0	162 56	*rtn	190 56	*rtn	218 56	*rtn
135 04	4	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 95	=	164 56	*rtn	192 56	*rtn	220 56	*rtn
137 65	×	165 56	*rtn	193 56	*rtn	221 56	*rtn
138 43	RCL	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 00	0	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

FIRST ORDER DIFFERENTIAL EQUATIONS

This program solves a number of differential equations of the form: $y' = f(x,y)$ with initial condition x_0, y_0.

A numerical, third-order Runge-Kutta approximation is used.

$$Y_{n+1} = y_n + 1/6K_1 + 2/3K_2 + 1/6K_3$$

$$\text{For } x_n = x_0 + nh \; (n = 1, 2, 3\ldots)$$

where: h = an increment specified by the user
$K_1 = hf(x_n, y_n)$
$K_2 = hf(x_n + 1/2h, y_n + 1/2K_1)$
$K_3 = hf(x_n + h, y_n - K_1 + 2K_2)$

NOTES:
1. $f(x_n, y_n)$ must be defined by a series of keystrokes assuming R_{01} contains x and R_{02} contains y.
2. There are 114 program locations, 14 data registers, and 4 user defined labels available for $f(x_n, y_n)$ input.
3. Only one level of subroutine can be used when inputting f(x), however f(x) input must not end in a subroutine if one is used.
4. $f(x_n, y_n)$ must be defined for all $n = 0, 1, 2, \ldots$
5. $h > 0$.
6. The code 56 for a return should be in the display after inputting the last entry of f(x). If not, it should be added.

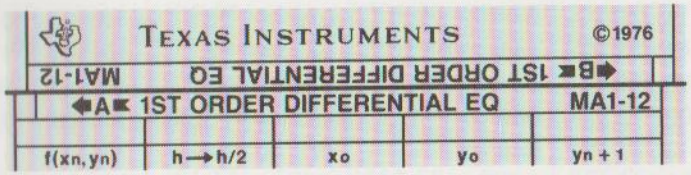
Reference: *Handbook of Mathematical Functions*, Abramowitz and Stegun, National Bureau of Standards, Applied Math Series No. 55, August 1966.

Example: Solve $y' = e^x - y$, for $h = 0.5$, $x_0 = 0$, $y_0 = 0$

Enter	Press	Display	Comments
	GTO A LRN	107 56	Prepared program for f(x)
	RCL 01	· ·	
	INV Inx	· ·	
	−	· ·	Stores f(x) directly into
	RCL 02	· ·	program
	=	117 56	
	LRN		Returns to calculate mode
.5	B	0.25	h/2
0	C	0.	x_0
0	D	0.	y_0
	E	.5208997934	y_1
	E	1.173528861	y_2
	E	2.124959463	y_3
	E	3.618340586	y_4

A table showing Runge-Kutta method versus the classical solution, $y = -1/2(e^{-x} - e^x)$, follows.

x	Classical Solution	Runge-Kutta Approximation
0	0	**0**
0.5	0.5210953095	**0.5208997934**
1.0	1.175201194	**1.173528861**
1.5	2.129279455	**2.124959463**
2.0	3.626860408	**3.618340586**
2.5	6.050204481	**6.035038566**
3.0	10.01787493	**9.992027721**
3.5	16.54262729	**16.49940211**
4.0	27.2899172	**27.21822086**
4.5	45.00301115	**44.88450684**
5.0	74.20321058	**74.00762798**



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter $f(x_n, y_n)$	$f(x_n, y_n)$	LRN			
4	Enter h	h	B			h/2
5	Enter x_o	x_o	C			x_o
6	Enter y_o	y_o	D			y_o
7	Calculate y_{n+1},		E			y_{n+1}
	for n = 1,2,3...					
	For new set of initial					
	conditions, go to Step 4					
	For new $f(x_n, y_n)$ go to					
	Step 2					

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 00	0	056 85	+	084 00	0
001 12	B	029 03	3	057 43	RCL	085 55	÷
002 55	÷	030 11	A	058 00	0	086 03	3
003 02	2	031 44	SUM	059 02	2	087 85	+
004 95	=	032 00	0	060 75	−	088 43	RCL
005 42	STO	033 03	3	061 03	3	089 00	0
006 00	0	034 42	STO	062 65	×	090 05	5
007 00	0	035 00	0	063 43	RCL	091 95	=
008 56	*rtn	036 04	4	064 00	0	092 14	D
009 46	*LBL	037 65	×	065 00	0	093 56	*rtn
010 13	C	038 43	RCL	066 65	×	094 46	*LBL
011 42	STO	039 00	0	067 43	RCL	095 19	*D'
012 00	0	040 00	0	068 00	0	096 43	RCL
013 01	1	041 95	=	069 04	4	097 00	0
014 56	*rtn	042 44	SUM	070 95	=	098 00	0
015 46	*LBL	043 00	0	071 42	STO	099 44	SUM
016 14	D	044 02	2	072 00	0	100 00	0
017 42	STO	045 19	*D'	073 02	2	101 01	1
018 00	0	046 65	×	074 19	*D'	102 43	RCL
019 02	2	047 04	4	075 44	SUM	103 00	0
020 42	STO	048 95	=	076 00	0	104 01	1
021 00	0	049 44	SUM	077 03	3	105 46	*LBL
022 05	5	050 00	0	078 43	RCL	106 11	A
023 56	*rtn	051 03	3	079 00	0	107 56	*rtn
024 46	*LBL	052 65	×	080 03	3	108 56	*rtn
025 15	E	053 43	RCL	081 65	×	109 56	*rtn
026 00	0	054 00	0	082 43	RCL	110 56	*rtn
027 42	STO	055 00	0	083 00	0	111 56	*rtn

*Denotes 2nd function key

REGISTERS

00 h	05 y_i	10	15
01 $x_i + h$	06	11	16
02 $y_i + hk_i$	07	12	17
03 Σk_i	08	13	18
04 k_i	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 56	*rtn	140 56	*rtn	168 56	*rtn	196 56	*rtn
113 56	*rtn	141 56	*rtn	169 56	*rtn	197 56	*rtn
114 56	*rtn	142 56	*rtn	170 56	*rtn	198 56	*rtn
115 56	*rtn	143 56	*rtn	171 56	*rtn	199 56	*rtn
116 56	*rtn	144 56	*rtn	172 56	*rtn	200 56	*rtn
117 56	*rtn	145 56	*rtn	173 56	*rtn	201 56	*rtn
118 56	*rtn	146 56	*rtn	174 56	*rtn	202 56	*rtn
119 56	*rtn	147 56	*rtn	175 56	*rtn	203 56	*rtn
120 56	*rtn	148 56	*rtn	176 56	*rtn	204 56	*rtn
121 56	*rtn	149 56	*rtn	177 56	*rtn	205 56	*rtn
122 56	*rtn	150 56	*rtn	178 56	*rtn	206 56	*rtn
123 56	*rtn	151 56	*rtn	179 56	*rtn	207 56	*rtn
124 56	*rtn	152 56	*rtn	180 56	*rtn	208 56	*rtn
125 56	*rtn	153 56	*rtn	181 56	*rtn	209 56	*rtn
126 56	*rtn	154 56	*rtn	182 56	*rtn	210 56	*rtn
127 56	*rtn	155 56	*rtn	183 56	*rtn	211 56	*rtn
128 56	*rtn	156 56	*rtn	184 56	*rtn	212 56	*rtn
129 56	*rtn	157 56	*rtn	185 56	*rtn	213 56	*rtn
130 56	*rtn	158 56	*rtn	186 56	*rtn	214 56	*rtn
131 56	*rtn	159 56	*rtn	187 56	*rtn	215 56	*rtn
132 56	*rtn	160 56	*rtn	188 56	*rtn	216 56	*rtn
133 56	*rtn	161 56	*rtn	189 56	*rtn	217 56	*rtn
134 56	*rtn	162 56	*rtn	190 56	*rtn	218 56	*rtn
135 56	*rtn	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 56	*rtn	164 56	*rtn	192 56	*rtn	220 56	*rtn
137 56	*rtn	165 56	*rtn	193 56	*rtn	221 56	*rtn
138 56	*rtn	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 56	*rtn	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

MATRIX INVERSION AND DETERMINANT (2 × 2)

This program will evaluate and take the inverse of a 2 × 2 matrix. Also, it will multiply 2 − (2 × 2) matrices together.

$$\text{Matrix A} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

The determinant of matrix A is $|A| = a_{11} \times a_{22} - a_{12} \times a_{21}$

The inverse of the matrix B is A^{-1} so that $A \times A^{-1} = 1$.

The product of two matrices is $C = A \times D$, where

$$c_{11} = a_{11} \times d_{11} + a_{12} \times d_{21} \qquad c_{21} = a_{21} \times d_{11} + a_{22} \times d_{21}$$
$$c_{12} = a_{11} \times d_{12} + a_{12} \times d_{22} \qquad c_{22} = a_{21} \times d_{12} + a_{22} \times d_{22}$$

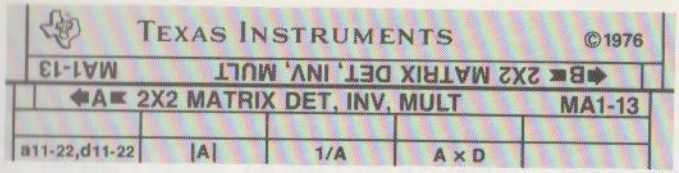
NOTES: 1. The determinant must be calculated before its inverse.
2. If the value of a determinant is 0, a flashing 0 is displayed.

Example: Let $A = \begin{pmatrix} 1 & 3 \\ 5 & 7 \end{pmatrix}$. Evaluate $|A|$ and find A^{-1}

Enter	Press	Display	Comments
1	A	1.	a_{11}
3	RUN	3.	a_{12}
5	RUN	5.	a_{21}
7	RUN	7.	a_{22}
	B	−8.	$\|A\|$
	C	−0.875	b_{11}
	RUN	0.375	b_{12}
	RUN	0.625	b_{21}
	RUN	−0.125	b_{22}

Example: Find the product $\begin{pmatrix} 1 & 3 \\ 5 & 7 \end{pmatrix} \times \begin{pmatrix} 2 & 4 \\ 6 & 8 \end{pmatrix}$.

Enter	Press	Display	Comments
1	A	1.	a_{11}
3	RUN	3.	a_{12}
5	RUN	5.	a_{21}
7	RUN	7.	a_{22}
2	RUN	2.	d_{11}
4	RUN	4.	d_{12}
6	RUN	6.	d_{21}
8	RUN	8.	d_{22}
	D	20.	c_{11}
	RUN	28.	c_{12}
	RUN	52.	c_{21}
	RUN	76.	c_{22}



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Enter Matrix A	a_{11}	A	a_{11}
		a_{12}	RUN	a_{12}
		a_{21}	RUN	a_{21}
		a_{22}	RUN	a_{22}
3	Enter Matrix D only if	d_{11}	RUN	d_{11}
	multiplication is desired	d_{12}	RUN	d_{12}
		d_{21}	RUN	d_{21}
		d_{22}	RUN	d_{22}
4	Evaluate determinant		B	$\|A\|$
5	Calculate inverse of Matrix A		C	b_{11}
			RUN	b_{12}
			RUN	b_{21}
			RUN	b_{22}
6	A × D = C		D	c_{11}
			RUN	c_{12}
			RUN	c_{21}
			RUN	c_{22}

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 12	B	056 46	*LBL	084 10	*E′
001 11	A	029 43	RCL	057 13	C	085 42	STO
002 48	*EXC	030 00	0	058 43	RCL	086 00	0
003 00	0	031 01	1	059 00	0	087 05	5
004 00	0	032 65	×	060 02	2	088 56	*rtn
005 01	1	033 43	RCL	061 94	+/−	089 05	5
006 48	*EXC	034 00	0	062 10	*E′	090 42	STO
007 00	0	035 04	4	063 42	STO	091 00	0
008 00	0	036 75	−	064 00	0	092 09	9
009 46	*LBL	037 43	RCL	065 06	6	093 46	*LBL
010 68	*8′	038 00	0	066 43	RCL	094 77	*4′
011 36	*IND	039 03	3	067 00	0	095 01	1
012 42	STO	040 65	×	068 03	3	096 44	SUM
013 00	0	041 43	RCL	069 94	+/−	097 00	0
014 00	0	042 00	0	070 10	*E′	098 09	9
015 56	*rtn	043 02	2	071 42	STO	099 36	*IND
016 48	*EXC	044 95	=	072 00	0	100 43	RCL
017 00	0	045 42	STO	073 07	7	101 00	0
018 00	0	046 00	0	074 43	RCL	102 09	9
019 85	+	047 00	0	075 00	0	103 56	*rtn
020 01	1	048 90	*if zro	076 01	1	104 41	GTO
021 95	=	049 69	*9′	077 10	*E′	105 77	*4′
022 48	*EXC	050 56	*rtn	078 42	STO	106 46	*LBL
023 00	0	051 46	*LBL	079 00	0	107 10	*E′
024 00	0	052 69	*9′	080 08	8	108 55	÷
025 41	GTO	053 20	*1/x	081 43	RCL	109 43	RCL
026 68	*8′	054 00	0	082 00	0	110 00	0
027 46	*LBL	055 56	*rtn	083 04	4	111 00	0

*Denotes 2nd function key

REGISTERS

00 Det	05 b_{11}	10	15
01 a_{11}	06 b_{12}	11	16
02 a_{12}	07 b_{21}	12	17
03 a_{21}	08 b_{22}	13	18
04 a_{22}	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 95	=	140 85	+	168 00	0	196 00	
113 56	*rtn	141 43	RCL	169 03	3	197 00	
114 46	*LBL	142 00	0	170 65	×	198 00	
115 14	D	143 02	2	171 43	RCL	199 00	
116 43	RCL	144 65	×	172 00	0	200 00	
117 00	0	145 43	RCL	173 06	6	201 00	
118 01	1	146 00	0	174 85	+	202 00	
119 65	×	147 08	8	175 43	RCL	203 00	
120 43	RCL	148 95	=	176 00	0	204 00	
121 00	0	149 56	*rtn	177 04	4	205 00	
122 05	5	150 43	RCL	178 65	×	206 00	
123 85	+	151 00	0	179 43	RCL	207 00	
124 43	RCL	152 03	3	180 00	0	208 00	
125 00	0	153 65	×	181 08	8	209 00	
126 02	2	154 43	RCL	182 95	=	210 00	
127 65	×	155 00	0	183 56	*rtn	211 00	
128 43	RCL	156 05	5	184 00		212 00	
129 00	0	157 85	+	185 00		213 00	
130 07	7	158 43	RCL	186 00		214 00	
131 95	=	159 00	0	187 00		215 00	
132 56	*rtn	160 04	4	188 00		216 00	
133 43	RCL	161 65	×	189 00		217 00	
134 00	0	162 43	RCL	190 00		218 00	
135 01	1	163 00	0	191 00		219 00	
136 65	×	164 07	7	192 00		220 00	
137 43	RCL	165 95	=	193 00		221 00	
138 00	0	166 56	*rtn	194 00		222 00	
139 06	6	167 43	RCL	195 00		223 00	

*Denotes 2nd function key

MATRIX INVERSION AND DETERMINANT (3 x 3)

This program will evaluate and take the inverse of a 3 x 3 matrix.

$$\text{Matrix A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

The determinant of matrix A is:

$$|A| = a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{13}a_{22}a_{31} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33}$$

The inverse of matrix A is $B = A^{-1}$, where $A \times A^{-1} = 1$.

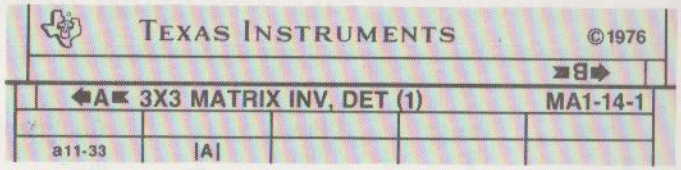
The elements of inverted matrix B are:

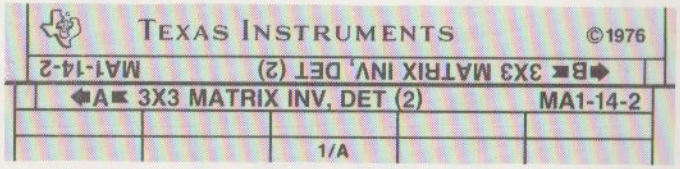
$$b_{11} = (a_{22}a_{33} - a_{32}a_{23}) / |A|$$
$$b_{21} = (a_{32}a_{13} - a_{12}a_{33}) / |A|$$
$$b_{31} = (a_{12}a_{23} - a_{22}a_{13}) / |A|$$
$$b_{12} = (a_{31}a_{23} - a_{21}a_{33}) / |A|$$
$$b_{22} = (a_{11}a_{33} - a_{31}a_{13}) / |A|$$
$$b_{32} = (a_{21}a_{13} - a_{11}a_{23}) / |A|$$
$$b_{13} = (a_{21}a_{32} - a_{31}a_{22}) / |A|$$
$$b_{23} = (a_{31}a_{12} - a_{11}a_{32}) / |A|$$
$$b_{33} = (a_{11}a_{22} - a_{21}a_{12}) / |A|$$

NOTES: 1. If $|A| = 0$, the display will flash 0 when [C] is pressed.
2. The determinant must be calculated before its inverse.

Example: Let $A = \begin{pmatrix} 2 & 4 & 9 \\ 1 & 3 & 5 \\ 7 & 8 & 6 \end{pmatrix}$. Evaluate $|A|$ and find A^{-1}

Enter	Press	Display	Comments
2	[A]	2.	a_{11}
4	[RUN]	4.	a_{12}
9	[RUN]	9.	a_{13}
1	[RUN]	1.	a_{21}
3	[RUN]	3.	a_{22}
5	[RUN]	5.	a_{23}
7	[RUN]	7.	a_{31}
8	[RUN]	8.	a_{32}
6	[RUN]	6.	a_{33}
	[B]	−45.	$\|A\|$
Enter card 2			
	[C]	.4888888889	b_{11}
	[RUN]	−1.066666667	b_{21}
	[RUN]	.1555555556	b_{31}
	[RUN]	−.6444444444	b_{12}
	[RUN]	1.133333333	b_{22}
	[RUN]	.0222222222	b_{32}
	[RUN]	.2888888889	b_{13}
	[RUN]	−.2666666667	b_{23}
	[RUN]	−.0444444444	b_{33}





USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Card 1 (Side A)					
2	Enter Matrix A	a_{11}	A			a_{11}
		a_{12}	RUN			a_{12}
		a_{13}	RUN			a_{13}
		a_{21}	RUN			a_{21}
		a_{22}	RUN			a_{22}
		a_{23}	RUN			a_{23}
		a_{31}	RUN			a_{31}
		a_{32}	RUN			a_{32}
		a_{33}	RUN			a_{33}
3	Calculate determinant		B			|A|
4	Enter Card 2 (A and B)					
5	Calculate inverse matrix		C			b_{11}
			RUN			b_{21}
			RUN			b_{31}
			RUN			b_{12}
			RUN			b_{22}
			RUN			b_{32}
			RUN			b_{13}
			RUN			b_{23}
			RUN			b_{33}

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 12	B	056 03	3	084 08	8
001 11	A	029 43	RCL	057 65	×	085 65	×
002 48	*EXC	030 00	0	058 43	RCL	086 43	RCL
003 00	0	031 09	9	059 00	0	087 00	0
004 00	0	032 65	×	060 04	4	088 06	6
005 01	1	033 43	RCL	061 65	×	089 75	−
006 48	*EXC	034 00	0	062 43	RCL	090 43	RCL
007 00	0	035 01	1	063 00	0	091 00	0
008 00	0	036 65	×	064 08	8	092 04	4
009 46	*LBL	037 43	RCL	065 75	−	093 65	×
010 68	*8′	038 00	0	066 43	RCL	094 43	RCL
011 36	*IND	039 05	5	067 00	0	095 00	0
012 42	STO	040 85	+	068 07	7	096 02	2
013 00	0	041 53	(	069 65	×	097 65	×
014 00	0	042 43	RCL	070 43	RCL	098 43	RCL
015 56	*rtn	043 00	0	071 00	0	099 00	0
016 48	*EXC	044 02	2	072 05	5	100 09	9
017 00	0	045 65	×	073 65	×	101 95	=
018 00	0	046 43	RCL	074 43	RCL	102 42	STO
019 85	+	047 00	0	075 00	0	103 01	1
020 01	1	048 06	6	076 03	3	104 09	9
021 95	=	049 65	×	077 75	−	105 56	*rtn
022 48	*EXC	050 43	RCL	078 43	RCL	106 00	
023 00	0	051 00	0	079 00	0	107 00	
024 00	0	052 07	7	080 01	1	108 00	
025 41	GTO	053 85	+	081 65	×	109 00	
026 68	*8′	054 43	RCL	082 43	RCL	110 00	
027 46	*LBL	055 00	0	083 00	0	111 00	

*Denotes 2nd function key

REGISTERS

00	05 a_{22}	10	15
01 a_{11}	06 a_{23}	11	16
02 a_{12}	07 a_{31}	12	17
03 a_{13}	08 a_{32}	13	18
04 a_{21}	09 a_{33}	14	19 Det.

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 75	–	056 42	STO	084 02	2
001 13	C	029 43	RCL	057 01	1	085 75	–
002 43	RCL	030 00	0	058 01	1	086 43	RCL
003 00	0	031 07	7	059 43	RCL	087 00	0
004 07	7	032 65	×	060 00	0	088 01	1
005 65	×	033 43	RCL	061 01	1	089 65	×
006 43	RCL	034 00	0	062 65	×	090 43	RCL
007 00	0	035 05	5	063 43	RCL	091 00	0
008 06	6	036 10	*E′	064 00	0	092 08	8
009 75	–	037 43	STO	065 09	9	093 10	*E′
010 43	RCL	038 01	1	066 75	–	094 42	STO
011 00	0	039 06	6	067 43	RCL	095 01	1
012 04	4	040 43	RCL	068 00	0	096 07	7
013 65	×	041 00	0	069 07	7	097 43	RCL
014 43	RCL	042 08	8	070 65	×	098 00	0
015 00	0	043 65	×	071 43	RCL	099 02	2
016 09	9	044 43	RCL	072 00	0	100 65	×
017 10	*E′	045 00	0	073 03	3	101 43	RCL
018 42	STO	046 03	3	074 10	*E′	102 00	0
019 01	1	047 75	–	075 42	STO	103 06	6
020 03	3	048 43	RCL	076 01	1	104 75	–
021 43	RCL	049 00	0	077 04	4	105 43	RCL
022 00	0	050 02	2	078 43	RCL	106 00	0
023 04	4	051 65	×	079 00	0	107 05	5
024 65	×	052 43	RCL	080 07	7	108 65	×
025 43	RCL	053 00	0	081 65	×	109 43	RCL
026 00	0	054 09	9	082 43	RCL	110 00	0
027 08	8	055 10	*E′	083 00	0	111 03	3

*Denotes 2nd function key

REGISTERS

00	05 a_{22}	10 b_{11}	15 b_{23}
01 a_{11}	06 a_{23}	11 b_{12}	16 b_{31}
02 a_{12}	07 a_{31}	12 b_{13}	17 b_{32}
03 a_{13}	08 a_{32}	13 b_{21}	18 b_{33}
04 a_{21}	09 a_{33}	14 b_{22}	19 Det.

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 10	*E′	140 00	0	168 06	6	196 43	RCL
113 42	STO	141 05	5	169 10	*E′	197 01	1
114 01	1	142 75	–	170 42	STO	198 09	9
115 02	2	143 43	RCL	171 01	1	199 95	=
116 43	RCL	144 00	0	172 00	0	200 70	*if err
117 00	0	145 04	4	173 56	*rtn	201 67	*7′
118 04	4	146 65	×	174 01	1	202 56	*rtn
119 65	×	147 43	RCL	175 01	1	203 46	*LBL
120 43	RCL	148 00	0	176 42	STO	204 67	*7′
121 00	0	149 02	2	177 00	0	205 00	0
122 03	3	150 10	*E′	178 00	0	206 20	*1/x
123 75	–	151 42	STO	179 46	*LBL	207 00	0
124 43	RCL	152 01	1	180 89	*3′	208 56	*rtn
125 00	0	153 08	8	181 36	*IND	209 00	
126 01	1	154 43	RCL	182 43	RCL	210 00	
127 65	×	155 00	0	183 00	0	211 00	
128 43	RCL	156 05	5	184 00	0	212 00	
129 00	0	157 65	×	185 56	*rtn	213 00	
130 06	6	158 43	RCL	186 01	1	214 00	
131 10	*E′	159 00	0	187 44	SUM	215 00	
132 42	STO	160 09	9	188 00	0	216 00	
133 01	1	161 75	–	189 00	0	217 00	
134 05	5	162 43	RCL	190 41	GTO	218 00	
135 43	RCL	163 00	0	191 89	*3′	219 00	
136 00	0	164 08	8	192 46	*LBL	220 00	
137 01	1	165 65	×	193 10	*E′	221 00	
138 65	×	166 43	RCL	194 95	=	222 00	
139 43	RCL	167 00	0	195 55	÷	223 00	

*Denotes 2nd function key

MATRIX ARITHMETIC (1)

Let $A = [a_{ij}]$ and $B = [b_{ij}]$ be two (m x n) matrices where $1 \le m \le 4$, $1 \le n \le 4$.

Then $pA + qB = C = [C_{ij}]$ is an (m x n) matrix such that

$$p\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} + q\begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix}$$

$$= \begin{bmatrix} pa_{11} + qb_{11} & pa_{12} + qb_{12} & pa_{13} + qb_{13} & pa_{14} + qb_{14} \\ pa_{21} + qb_{21} & pa_{22} + qb_{22} & pa_{23} + qb_{23} & pa_{24} + qb_{24} \\ pa_{31} + qb_{31} & pa_{32} + qb_{32} & pa_{33} + qb_{33} & pa_{34} + qb_{34} \\ pa_{41} + qb_{41} & pa_{42} + qb_{42} & pa_{43} + qb_{43} & pa_{44} + qb_{44} \end{bmatrix}$$

where p and q are constants.

NOTES:
1. If p or q is unity, enter a 1 on [E]. If B is to be subtracted from A, enter a −1 on [E] prior to entering the matrix B.
2. It is not necessary to enter zeros for elements outside the (m x n) matrix if $m < 4$ or $n < 4$.
3. Chain addition/subtraction of matrices is possible by repeating steps 3-19 for each additional matrix.
4. The elements c_{ij} of the resulting matrix C are not destroyed during the recall operation.

Reference: *Computer Methods for Science and Engineering*, Robert L. LaFara, Hayden Book Company, 1973.

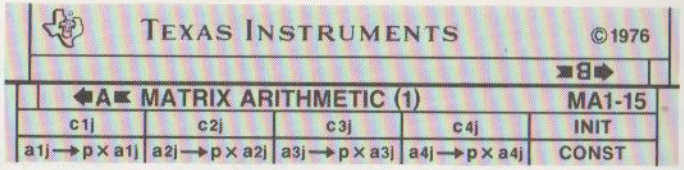
Example: $\begin{bmatrix} 3 & 1 \\ 2 & 5 \\ 4 & 7 \end{bmatrix} - \begin{bmatrix} 0 & 2 \\ 1 & 6 \\ 3 & 9 \end{bmatrix}$

Note that p = 1 and q = −1

Enter	Press	Display	Comments
	[2nd] [E']	0.	Initialize
1	[E]	1.	p
3	[A]	3.	$p \times a_{11}$
1	[RUN]	1.	$p \times a_{12}$
2	[B]	2.	$p \times a_{21}$
5	[RUN]	5.	$p \times a_{22}$
4	[C]	4.	$p \times a_{31}$
7	[RUN]	7.	$p \times a_{32}$
1	[+/−] [E]	−1.	q
0	[A]	0.	$q \times b_{11}$
2	[RUN]	−2.	$q \times b_{12}$
1	[B]	−1.	$q \times b_{21}$
6	[RUN]	−6.	$q \times b_{22}$
3	[C]	−3.	$q \times b_{31}$
9	[RUN]	−9.	$q \times b_{32}$
	[2nd] [A']	3.	c_{11}
	[RUN]	−1.	c_{12}
	[2nd] [B']	1.	c_{21}
	[RUN]	−1.	c_{22}
	[2nd] [C']	1.	c_{31}
	[RUN]	−2.	c_{32}

Example: $4\begin{bmatrix} 1 & 3 & 5 & 7 \\ 2 & 4 & 6 & 8 \end{bmatrix} + .5\begin{bmatrix} -2 & 6 & 4 & 7 \\ 3 & -1 & -8 & 3 \end{bmatrix} = \begin{bmatrix} 3 & 15 & 22 & 31.5 \\ 9.5 & 15.5 & 20 & 33.5 \end{bmatrix}$

Example: $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 2 & 1 \\ 7 & 3 & -6 \end{bmatrix} - 2\begin{bmatrix} 1 & 3 & -2 \\ 5 & 4 & 1 \\ 3 & 1 & 3 \end{bmatrix} - \begin{bmatrix} 1 & 1 & 1 \\ 6 & -4 & 2 \\ 7 & 5 & 3 \end{bmatrix} + 4\begin{bmatrix} 1 & 0 & 3 \\ 0 & 2 & 1 \\ 5 & 6 & 7 \end{bmatrix} = \begin{bmatrix} 2 & -5 & 18 \\ -12 & 6 & 1 \\ 14 & 20 & 13 \end{bmatrix}$



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A only)			
2	Initialize		2nd F'	0
3	Enter constant	p (q)	E	p
4	Enter matrix	a_{11} (b_{11})	A	p × a_{11}
5		a_{12} (b_{12})	RUN	p × a_{12}
6		a_{13} (b_{13})	RUN	p × a_{13}
7		a_{14} (b_{14})	RUN	p × a_{14}
8		a_{21} (b_{21})	B	p × a_{21}
9		a_{22} (b_{22})	RUN	p × a_{22}
10		a_{23} (b_{23})	RUN	p × a_{23}
11		a_{24} (b_{24})	RUN	p × a_{24}
12		a_{31} (b_{31})	C	p × a_{31}
13		a_{32} (b_{32})	RUN	p × a_{32}
14		a_{33} (b_{33})	RUN	p × a_{33}
15		a_{34} (b_{34})	RUN	p × a_{34}
16		a_{41} (b_{41})	D	p × a_{41}
17		a_{42} (b_{42})	RUN	p × a_{42}
18		a_{43} (b_{43})	RUN	p × a_{43}
19		a_{44} (b_{44})	RUN	p × a_{44}

(Repeat 3-19 for second and additional matrices)

Continued on next page

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
20	Recall matrix (c_{ij})		2nd A'	c_{11}
21			RUN	c_{12}
22			RUN	c_{13}
23			RUN	c_{14}
24			2nd B'	c_{21}
25			RUN	c_{22}
26			RUN	c_{23}
27			RUN	c_{24}
28			2nd C'	c_{31}
29			RUN	c_{32}
30			RUN	c_{33}
31			RUN	c_{34}
32			2nd D'	c_{41}
33			RUN	c_{42}
34			RUN	c_{43}
35			RUN	c_{44}

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 43	RCL	056 46	*LBL	084 44	SUM
001 10	*E'	029 00	0	057 13	C	085 01	1
002 47	*CMs	030 00	0	058 42	STO	086 08	8
003 25	CLR	031 95	=	059 01	1	087 36	*IND
004 56	*rtn	032 36	*IND	060 07	7	088 43	RCL
005 46	*LBL	033 44	SUM	061 09	9	089 01	1
006 15	E	034 01	1	062 41	GTO	090 08	8
007 42	STO	035 08	8	063 32	sin	091 56	*rtn
008 00	0	036 48	*EXC	064 46	*LBL	092 41	GTO
009 00	0	037 01	1	065 14	D	093 33	cos
010 56	*rtn	038 08	8	066 42	STO	094 46	*LBL
011 46	*LBL	039 85	+	067 01	1	095 17	*B'
012 11	A	040 01	1	068 07	7	096 04	4
013 42	STO	041 95	=	069 01	1	097 41	GTO
014 01	1	042 48	*EXC	070 03	3	098 52	EE
015 07	7	043 01	1	071 41	GTO	099 46	*LBL
016 01	1	044 08	8	072 32	sin	100 18	*C'
017 46	*LBL	045 56	*rtn	073 46	*LBL	101 08	8
018 32	sin	046 41	GTO	074 16	*A'	102 41	GTO
019 42	STO	047 24	CE	075 00	0	103 52	EE
020 01	1	048 46	*LBL	076 46	*LBL	104 46	*LBL
021 08	8	049 12	B	077 52	EE	105 19	*D'
022 43	RCL	050 42	STO	078 42	STO	106 01	1
023 01	1	051 01	1	079 01	1	107 02	2
024 07	7	052 07	7	080 08	8	108 41	GTO
025 46	*LBL	053 05	5	081 46	*LBL	109 52	EE
026 24	CE	054 41	GTO	082 33	cos	110 00	0
027 65	×	055 32	sin	083 01	1	111 00	0

*Denotes 2nd function key

REGISTERS

00 Used	05 C_{21}	10 C_{32}	15 C_{43}
01 C_{11}	06 C_{22}	11 C_{33}	16 C_{44}
02 C_{12}	07 C_{23}	12 C_{34}	17 Used
03 C_{13}	08 C_{24}	13 C_{41}	18 Used
04 C_{14}	09 C_{31}	14 C_{42}	19

FLAGS

0	1	2	3	4

MATRIX ARITHMETIC (2)

The product AB in that order of the m x p matrix $A = [a_{ij}]$ and the p x n matrix $B = [b_{ij}]$ is the m x n matrix $C = [c_{ij}]$ where $0 \le m \le 3$, $0 \le n \le 3, 0 \le p \le 3$.

$$AB = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{32} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$$

$$= \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} + a_{13}b_{31} & a_{11}b_{12} + a_{12}b_{22} + a_{13}b_{32} & a_{11}b_{13} + a_{12}b_{23} + a_{13}b_{33} \\ a_{21}b_{11} + a_{22}b_{21} + a_{23}b_{31} & a_{21}b_{12} + a_{22}b_{22} + a_{23}b_{32} & a_{21}b_{13} + a_{22}b_{23} + a_{23}b_{33} \\ a_{31}b_{11} + a_{32}b_{21} + a_{33}b_{31} & a_{31}b_{12} + a_{32}b_{22} + a_{33}b_{32} & a_{31}b_{13} + a_{32}b_{23} + a_{33}b_{33} \end{bmatrix}$$

$$= \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} = C$$

NOTE: if $m < 3$, $n < 3$, $p < 3$, it is not necessary to enter zeros for the remainder of the matrix elements. Matrix 'A' is not destroyed, thus you may do constant multiplication by matrix 'A'.

Reference: *Computer Methods for Science and Engineering*, Robert L. LaFara, Hayden Book Company, 1973.

Example: Evaluate $\begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$

Enter	Press	Display	Comments
	E	0.	Initialize
2	A	1.	a_{11}
3	RUN	1.	a_{12}
1	B	1.	a_{21}
2	RUN	1.	a_{22}
	D	1.	Multiply
1	A	0.	$a_{31} \times b_{11}$
2	RUN	0.	$a_{31} \times b_{21}$
3	B	0.	$a_{32} \times b_{12}$
4	RUN	0.	$a_{32} \times b_{22}$
	2nd A'	11.	c_{11}
	RUN	16.	c_{12}
	2nd B'	7.	c_{21}
	RUN	10.	c_{22}

Example: $[1\ 2\ 3] \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} = [32]$

Example: $\begin{bmatrix} 1 & 4 & -2 \\ 6 & 3 & 0 \\ 6 & -1 & -2 \end{bmatrix} \begin{bmatrix} 0 & 4 & 2 \\ -1 & 2 & 6 \\ 4 & 3 & 2 \end{bmatrix} = \begin{bmatrix} -12 & 6 & 22 \\ -3 & 30 & 30 \\ -7 & 16 & 2 \end{bmatrix}$

TEXAS INSTRUMENTS ©1976

MA1-16 MATRIX ARITHMETIC (2) B

A MATRIX ARITHMETIC (2) MA1-16

c1j	c2j	c3j		
a1j (b1j)	a2j (b2j)	a3j (b3j)	MULT	INIT

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Initialize		E	
3	Enter matrix	a_{11} (b_{11})	A	$a_{31} \times b_{11}$
4		a_{12} (b_{12})	RUN	$a_{31} \times b_{12}$
5		a_{13} (b_{13})	RUN	$a_{31} \times b_{13}$
6		a_{21} (b_{21})	B	$a_{32} \times b_{21}$
7		a_{22} (b_{22})	RUN	$a_{32} \times b_{22}$
8		a_{23} (b_{23})	RUN	$a_{32} \times b_{23}$
9		a_{31} (b_{31})	C	$a_{33} \times b_{31}$
10		a_{32} (b_{32})	RUN	$a_{33} \times b_{32}$
11		a_{33} (b_{33})	RUN	$a_{33} \times b_{33}$
	(If Matrix B has been			
	entered go to 13)			
12	Setup for multiply		D	
	(Repeat 3-11 for Matrix B)			
13	Recall Matrix C		2nd A'	c_{11}
			RUN	c_{12}
			RUN	c_{13}
			2nd B'	c_{21}
			RUN	c_{22}
			RUN	c_{23}
			2nd C'	c_{31}
			RUN	c_{32}
			RUN	c_{33}
14	To use Matrix A again, ——	go to Step 12		

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 25	CLR	028 52	EE	056 56	*rtn	084 00	0
001 56	*rtn	029 19	*D′	057 46	*LBL	085 00	0
002 46	*LBL	030 44	SUM	058 42	STO	086 07	7
003 15	E	031 00	0	059 19	*D′	087 51	SBR
004 47	*CMs	032 01	1	060 44	SUM	088 24	CE
005 86	*rset	033 10	*E′	061 00	0	089 56	*rtn
006 46	*LBL	034 44	SUM	062 03	3	090 42	STO
007 19	*D′	035 00	0	063 10	*E′	091 00	0
008 42	STO	036 04	4	064 44	SUM	092 00	0
009 01	1	037 10	*E′	065 00	0	093 07	7
010 09	9	038 44	SUM	066 06	6	094 51	SBR
011 46	*LBL	039 00	0	067 10	*E′	095 42	STO
012 10	*E′	040 07	7	068 44	SUM	096 56	*rtn
013 03	3	041 56	*rtn	069 00	0	097 46	*LBL
014 44	SUM	042 46	*LBL	070 09	9	098 88	*2′
015 01	1	043 24	CE	071 56	*rtn	099 08	8
016 09	9	044 19	*D′	072 46	*LBL	100 51	SBR
017 43	RCL	045 44	SUM	073 14	D	101 52	EE
018 00	0	046 00	0	074 50	*st flg	102 56	*rtn
019 00	0	047 02	2	075 00	0	103 42	STO
020 65	×	048 10	*E′	076 56	*rtn	104 00	0
021 36	*IND	049 44	SUM	077 46	*LBL	105 00	0
022 43	RCL	050 00	0	078 87	*1′	106 08	8
023 01	1	051 05	5	079 07	7	107 51	SBR
024 09	9	052 10	*E′	080 51	SBR	108 24	CE
025 95	=	053 44	SUM	081 52	EE	109 56	*rtn
026 56	*rtn	054 00	0	082 56	*rtn	110 42	STO
027 46	*LBL	055 08	8	083 42	STO	111 00	0

*Denotes 2nd function key

REGISTERS

00 Used	05 c_{22}	10 a_{11}	15 a_{23}
01 c_{11}	06 c_{23}	11 a_{12}	16 a_{31}
02 c_{12}	07 c_{31}	12 a_{13}	17 a_{32}
03 c_{13}	08 c_{32}	13 a_{21}	18 a_{33}
04 c_{21}	09 c_{33}	14 a_{22}	19 Used

FLAGS

0 Used	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00	0	140 00	0	168 00	0	196 00	0
113 08	8	141 00	0	169 00	0	197 46	*LBL
114 51	SBR	142 60	*if flg	170 60	*if flg	198 65	×
115 42	STO	143 00	0	171 00	0	199 01	1
116 56	*rtn	144 87	*1′	172 88	*2′	200 44	SUM
117 46	*LBL	145 01	1	173 01	1	201 00	0
118 89	*3′	146 00	0	174 03	3	202 00	0
119 09	9	147 46	*LBL	175 41	GTO	203 25	CLR
120 51	SBR	148 32	sin	176 32	sin	204 36	*IND
121 52	EE	149 48	*EXC	177 46	*LBL	205 43	RCL
122 56	*rtn	150 00	0	178 13	C	206 00	0
123 42	STO	151 00	0	179 42	STO	207 00	0
124 00	0	152 46	*LBL	180 00	0	208 56	*rtn
125 00	0	153 33	cos	181 00	0	209 41	GTO
126 09	9	154 36	*IND	182 60	*if flg	210 65	×
127 51	SBR	155 42	STO	183 00	0	211 46	*LBL
128 24	CE	156 00	0	184 89	*3′	212 17	*B′
129 56	*rtn	157 00	0	185 01	1	213 03	3
130 42	STO	158 01	1	186 06	6	214 41	GTO
131 00	0	159 44	SUM	187 41	GTO	215 85	+
132 00	0	160 00	0	188 32	sin	216 46	*LBL
133 09	9	161 00	0	189 46	*LBL	217 18	*C′
134 51	SBR	162 56	*rtn	190 16	*A′	218 06	6
135 42	STO	163 41	GTO	191 00	0	219 41	GTO
136 56	*rtn	164 33	cos	192 46	*LBL	220 85	+
137 46	*LBL	165 46	*LBL	193 85	+	221 00	
138 11	A	166 12	B	194 42	STO	222 00	
139 42	STO	167 42	STO	195 00	0	223 00	

*Denotes 2nd function key

GENERAL MATRIX PRODUCT

This program will calculate the product AB in that order of the m x p matrix $A = [a_{ij}]$ and the p x n matrix $B = [b_{ij}]$, where $0 \leq p \leq 18$. The result is the m x n matrix $C = [c_{ij}]$.

Procedure: Enter row i of matrix A and column j of matrix B. The result is element c_{ij}. Once entered, row i of matrix A is stored so only one entry of row i is necessary to calculate the c_{ij}'s associated with row i.

Reference: *Computer Methods for Science and Engineering*, Robert L. LaFara, Hayden Book Company, 1973.

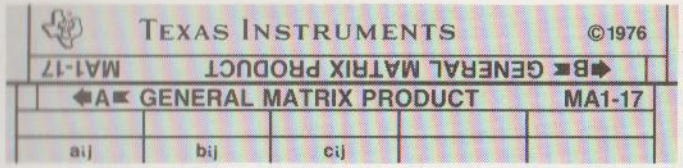
Example:

$$\begin{bmatrix} 2 & -1 & 3 & 4 & 7 & 12 \\ 0 & 5 & 4 & 3 & 2 & 1 \\ 8 & 4 & 7 & 3 & 10 & -4 \\ 6 & 11 & 4 & 21 & -4 & -3 \end{bmatrix} \begin{bmatrix} 1 & 6 & 0 & -1 \\ 7 & 5 & 4 & -3 \\ 3 & 4 & 2 & 4 \\ -4 & 1 & 1 & -7 \\ 11 & 2 & -8 & 6 \\ 2 & 3 & -2 & 5 \end{bmatrix} = \begin{bmatrix} 89 & 73 & -74 & 87 \\ 59 & 51 & 13 & -3 \\ 147 & 107 & -39 & 27 \\ -39 & 111 & 111 & -209 \end{bmatrix}$$

Solving for the row 1, matrix A versus column 1, matrix B:

Enter	Press	Display	Comments
2	A	2.	a_{i1}/display j + 1
1	+/− RUN	3.	a_{i2}
3	RUN	4.	a_{i3}
4	RUN	5.	a_{i4}
7	RUN	6.	a_{i5}
12	RUN	7.	a_{i6}
1	B	2.	b_{1j}
7	RUN	3.	b_{2j}
3	RUN	4.	b_{3j}
4	+/− RUN	5.	b_{4j}
11	RUN	6.	b_{5j}
2	RUN	7.	b_{6j}
	C	89.	c_{ij} (A•B)

The complete results are listed beside the problem above.



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A only)			
2	Enter row i Matrix A	a_{i1}	A	2.
		a_{i2}	RUN	3.
		⋮	⋮	⋮
		a_{ij}	RUN	i + 1
3	Enter column j Matrix B	b_{1j}	B	2.
		b_{2j}	RUN	3.
		⋮	⋮	⋮
		b_{ij}	RUN	j + 1
4	Calculate c_{ij}		C	c_{ij}(A • B)
	(Repeat Steps 3-4 for each			
	column j then enter new row			
	(Step 2) and again compute			
	each column j)			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 25	CLR	028 52	EE	056 09	9	084 01	1
001 56	*rtn	029 46	*LBL	057 14	D	085 42	STO
002 46	*LBL	030 12	B	058 81	HLT	086 01	1
003 15	E	031 42	STO	059 41	GTO	087 09	9
004 47	*CMs	032 01	1	060 24	CE	088 56	*rtn
005 86	*rset	033 09	9	061 46	*LBL	089 00	
006 46	*LBL	034 00	0	062 13	C	090 00	
007 11	A	035 42	STO	063 43	RCL	091 00	
008 42	STO	036 00	0	064 00	0	092 00	
009 01	1	037 00	0	065 00	0	093 00	
010 09	9	038 01	1	066 56	*rtn	094 00	
011 01	1	039 48	*EXC	067 46	*LBL	095 00	
012 48	*EXC	040 01	1	068 14	D	096 00	
013 01	1	041 09	9	069 43	RCL	097 00	
014 09	9	042 46	*LBL	070 01	1	098 00	
015 46	*LBL	043 24	CE	071 09	9	099 00	
016 52	EE	044 65	×	072 75	−	100 00	
017 36	*IND	045 36	*IND	073 01	1	101 00	
018 42	STO	046 43	RCL	074 09	9	102 00	
019 01	1	047 01	1	075 95	=	103 00	
020 09	9	048 09	9	076 90	*if zro	104 00	
021 01	1	049 95	=	077 16	*A′	105 00	
022 44	SUM	050 44	SUM	078 43	RCL	106 00	
023 01	1	051 00	0	079 01	1	107 00	
024 09	9	052 00	0	080 09	9	108 00	
025 14	D	053 01	1	081 56	*rtn	109 00	
026 81	HLT	054 44	SUM	082 46	*LBL	110 00	
027 41	GTO	055 01	1	083 16	*A′	111 00	

*Denotes 2nd function key

REGISTERS

00 a_{i1}	05 a_{i6}	10 a_{i11}	15 a_{i16}
01 a_{i2}	06 a_{i7}	11 a_{i12}	16 a_{i17}
02 a_{i3}	07 a_{i8}	12 a_{i13}	17 a_{i18}
03 a_{i4}	08 a_{i9}	13 a_{i14}	18 c_{ij}
04 a_{i5}	09 a_{i10}	14 a_{i15}	19 Used

FLAGS

0	1	*2	3	4

VECTOR OPERATIONS

Given 2 three-dimensional vectors, this program will compute:

- The magnitude of each vector
- The cross product
- The dot product.

Let A be a vector in space and A_1, A_2, A_3 be the magnitudes of the projections of A along three mutually perpendicular lines (the coordinate axes). Then

$$A = A_1 i + A_2 j + A_3 k$$

where i, j, and k are 3 vectors of unit magnitude along the coordinate axes.

To compute the magnitude:

$$|A| = \sqrt{A_1^2 + A_2^2 + A_3^2}$$

To compute the dot product:

$$A \cdot B = A_1 \cdot B_1 + A_2 \cdot B_2 + A_3 \cdot B_3$$

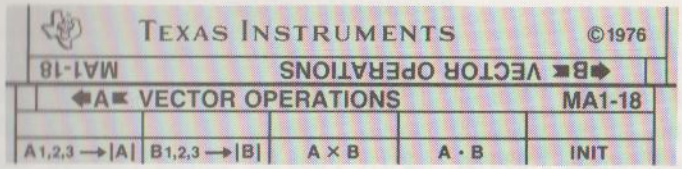
To compute the cross product:

$$A \times B = C = (A_2B_3 - A_3B_2,\ A_3B_1 - A_1B_3,\ A_1B_2 - A_2B_1) = (C_1,\ C_2,\ C_3)$$

Example: Given $A = 2i + 3j + 6k$
$B = 1i + 4j + 8k$

Find: Magnitude, cross product, dot product.

Enter	Press	Display	Comments
	E		Initialize
2	A	2.	A_1
3	A	3.	A_2
6	A	7.	$\|A\|$
1	B	1.	B_1
4	B	4.	B_2
8	B	9.	$\|B\|$
	C	0.	C_1, $A \times B$
	C	−10.	C_2, $A \times B$
	C	5.	C_3, $A \times B$
	D	62.	$A \cdot B$



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Initialize		E	
3	Enter A_1	A_1	A	A_1
4	Enter A_2	A_2	A	A_2
5	Enter A_3	A_3	A	$\|A\|$
6	Enter B_1	B_1	B	B_1
7	Enter B_2	B_2	B	B_2
8	Enter B_3	B_3	B	$\|B\|$
9	Compute $A \times B = C$		C	C_1
			C	C_2
			C	C_3
10	Compute $A \cdot B$		D	$A \cdot B$

$\vec{A} \cdot \vec{B} = A \cdot B \cdot \cos\theta$ Dot Product

$\vec{A} \times \vec{B} = A \cdot B \cdot \sin\theta$ Cross Product

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 81	HLT	028 42	STO	056 46	*LBL	084 35	$\sqrt[x]{y}$
001 86	*rset	029 00	0	057 12	B	085 42	STO
002 46	*LBL	030 02	2	058 60	*if flg	086 00	0
003 15	E	031 50	*st flg	059 00	0	087 06	6
004 25	CLR	032 02	2	060 40	*x^2	088 40	*x^2
005 47	*CMs	033 56	*rtn	061 60	*if flg	089 85	+
006 86	*rset	034 46	*LBL	062 01	1	090 43	RCL
007 46	*LBL	035 30	*$\sqrt{x}$	063 45	y^x	091 00	0
008 11	A	036 42	STO	064 42	STO	092 05	5
009 60	*if flg	037 00	0	065 00	0	093 40	*x^2
010 03	3	038 03	3	066 04	4	094 85	+
011 40	*x^2	039 40	*x^2	067 50	*st flg	095 43	RCL
012 60	*if flg	040 85	+	068 03	3	096 00	0
013 01	1	041 43	RCL	069 50	*st flg	097 04	4
014 65	×	042 00	0	070 01	1	098 40	*x^2
015 42	STO	043 02	2	071 56	*rtn	099 95	=
016 00	0	044 40	*x^2	072 46	*LBL	100 30	*$\sqrt{x}$
017 01	1	045 85	+	073 45	y^x	101 42	STO
018 50	*st flg	046 43	RCL	074 60	*if flg	102 00	0
019 00	0	047 00	0	075 02	2	103 08	8
020 50	*st flg	048 01	1	076 35	$\sqrt[x]{y}$	104 86	*rset
021 01	1	049 40	*x^2	077 42	STO	105 46	*LBL
022 56	*rtn	050 95	=	078 00	0	106 13	C
023 46	*LBL	051 30	*$\sqrt{x}$	079 05	5	107 60	*if flg
024 65	×	052 42	STO	080 50	*st flg	108 03	3
025 60	*if flg	053 00	0	081 02	2	109 42	STO
026 02	2	054 07	7	082 56	*rtn	110 43	RCL
027 30	*$\sqrt{x}$	055 86	*rset	083 46	*LBL	111 00	0

*Denotes 2nd function key

REGISTERS

00	05 B_2	10	15
01 A_1	06 B_3	11 C_1	16
02 A_2	07 |A|	12 C_2	17
03 A_3	08 |B|	13 C_3	18
04 B_1	09	14 A•B	19

FLAGS

0 Used	1 Used	2 Used	3 Used	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 02	2	140 65	×	168 75	−	196 00	0
113 65	×	141 43	RCL	169 43	RCL	197 05	5
114 43	RCL	142 00	0	170 00	0	198 85	+
115 00	0	143 04	4	171 02	2	199 43	RCL
116 06	6	144 75	−	172 65	×	200 00	0
117 75	−	145 43	RCL	173 43	RCL	201 03	3
118 43	RCL	146 00	0	174 00	0	202 65	×
119 00	0	147 01	1	175 04	4	203 43	RCL
120 03	3	148 65	×	176 95	=	204 00	0
121 65	×	149 43	RCL	177 42	STO	205 06	6
122 43	RCL	150 00	0	178 01	1	206 95	=
123 00	0	151 06	6	179 03	3	207 42	STO
124 05	5	152 95	=	180 86	*rset	208 01	1
125 95	=	153 42	STO	181 46	*LBL	209 04	4
126 42	STO	154 01	1	182 14	D	210 56	*rtn
127 01	1	155 02	2	183 43	RCL	211 46	*LBL
128 01	1	156 50	*st flg	184 00	0	212 40	*x^2
129 50	*st flg	157 04	4	185 01	1	213 00	0
130 03	3	158 56	*rtn	186 65	×	214 20	*1/x
131 56	*rtn	159 46	*LBL	187 43	RCL	215 86	*rset
132 46	*LBL	160 43	RCL	188 00	0	216 00	
133 42	STO	161 43	RCL	189 04	4	217 00	
134 60	*if flg	162 00	0	190 85	+	218 00	
135 04	4	163 01	1	191 43	RCL	219 00	
136 43	RCL	164 65	×	192 00	0	220 00	
137 43	RCL	165 43	RCL	193 02	2	221 00	
138 00	0	166 00	0	194 65	×	222 00	
139 03	3	167 05	5	195 43	RCL	223 00	

*Denotes 2nd function key

PARTIAL SUMS AND PRODUCTS

This program is designed to calculate

$$\sum_{k=n}^{N} f(k,x) \quad \text{or} \quad \prod_{k=n}^{N} f(k,x)$$

where: $n = 0, 1, 2\ldots$
$N = 0, 1, 2\ldots$
$N \geqq n$
N and n must be integers.

NOTES:
1. f(x) must be defined by a series of keystrokes.
2. There are 125 program locations, 17 data registers (R_{03}-R_{19}), and 6 user defined labels available for f(k,x) input, k is in the display register when f(k,x) is being input.
3. f(k,x) input must not end in a subroutine if one is used to define f(k,x)
4. The code (56) for a rtn should be in the display after inputting the last entry for f(k,x). If not, it should be added.
5. Only one level of subroutine can be used for inputting f(k,x).

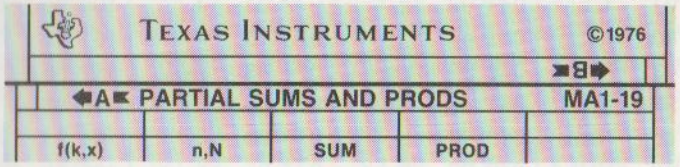
Example: Evaluate $\sum_{k=2}^{5} (3)^k$

Enter	Press	Display	Comments
	GTO A LRN	105 56	Initialize
3	y^x	. .	
	RCL 00	. .	Stores f(x) directly into
	=	111 56	program
	LRN	0.	Return to calculate mode
2	B	2.	n
5	RUN	5.	N
	C	360.	Σ f(x)

Example: Evaluate $\prod_{k=0}^{2} [(2.5)^k - (.2)k]$

Enter	Press	Display	Comments
	GTO A LRN	105 56*	Initialize
2.5	y^x	. .	
	RCL 00	. .	Stores f(x) directly into
	−	. .	program
.2	× RCL 00	. .	
	=	120 56	
	LRN		Returns to calculate mode
0	B	0.	n
2	RUN	2.	N
	D	13.455	Π f(x)

*Instruction may be other than 56 after the program has been executed.



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Initialize		GTO	A	LRN	
3	Enter f(k,x)	f(k,x)	LRN			
4	Enter n	n	B			n
5	Enter N	N	RUN			N
6	Calculate SUM		C			SUM
	OR					
7	Calculate Product		D			Product

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 00	0	056 22	INV	084 02	2
001 12	B	029 95	=	057 90	*if zro	085 46	*LBL
002 42	STO	030 80	*if pos	058 32	sin	086 33	cos
003 00	0	031 45	y^x	059 43	RCL	087 43	RCL
004 00	0	032 23	lnx	060 00	0	088 00	0
005 80	*if pos	033 46	*LBL	061 02	2	089 00	0
006 52	EE	034 45	y^x	062 56	*rtn	090 11	A
007 23	lnx	035 43	RCL	063 46	*LBL	091 49	*PROD
008 46	*LBL	036 00	0	064 24	CE	092 00	0
009 52	EE	037 01	1	065 01	1	093 02	2
010 43	RCL	038 56	*rtn	066 44	SUM	094 51	SBR
011 00	0	039 46	*LBL	067 00	0	095 24	CE
012 00	0	040 13	C	068 00	0	096 22	INV
013 56	*rtn	041 00	0	069 85	+	097 90	*if zro
014 42	STO	042 42	STO	070 43	RCL	098 33	cos
015 00	0	043 00	0	071 00	0	099 43	RCL
016 01	1	044 02	2	072 01	1	100 00	0
017 80	*if pos	045 46	*LBL	073 75	−	101 02	2
018 43	RCL	046 32	sin	074 43	RCL	102 56	*rtn
019 23	lnx	047 43	RCL	075 00	0	103 46	*LBL
020 46	*LBL	048 00	0	076 00	0	104 11	A
021 43	RCL	049 00	0	077 95	=	105 56	*rtn
022 43	RCL	050 11	A	078 56	*rtn	106 56	*rtn
023 00	0	051 44	SUM	079 46	*LBL	107 56	*rtn
024 01	1	052 00	0	080 14	D	108 56	*rtn
025 75	−	053 02	2	081 01	1	109 56	*rtn
026 43	RCL	054 51	SBR	082 42	STO	110 56	*rtn
027 00	0	055 24	CE	083 00	0	111 56	*rtn

*Denotes 2nd function key

REGISTERS

00 k	05	10	15
01 Used	06	11	16
02 Used	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 56	*rtn	140 56	*rtn	168 56	*rtn	196 56	*rtn
113 56	*rtn	141 56	*rtn	169 56	*rtn	197 56	*rtn
114 56	*rtn	142 56	*rtn	170 56	*rtn	198 56	*rtn
115 56	*rtn	143 56	*rtn	171 56	*rtn	199 56	*rtn
116 56	*rtn	144 56	*rtn	172 56	*rtn	200 56	*rtn
117 56	*rtn	145 56	*rtn	173 56	*rtn	201 56	*rtn
118 56	*rtn	146 56	*rtn	174 56	*rtn	202 56	*rtn
119 56	*rtn	147 56	*rtn	175 56	*rtn	203 56	*rtn
120 56	*rtn	148 56	*rtn	176 56	*rtn	204 56	*rtn
121 56	*rtn	149 56	*rtn	177 56	*rtn	205 56	*rtn
122 56	*rtn	150 56	*rtn	178 56	*rtn	206 56	*rtn
123 56	*rtn	151 56	*rtn	179 56	*rtn	207 56	*rtn
124 56	*rtn	152 56	*rtn	180 56	*rtn	208 56	*rtn
125 56	*rtn	153 56	*rtn	181 56	*rtn	209 56	*rtn
126 56	*rtn	154 56	*rtn	182 56	*rtn	210 56	*rtn
127 56	*rtn	155 56	*rtn	183 56	*rtn	211 56	*rtn
128 56	*rtn	156 56	*rtn	184 56	*rtn	212 56	*rtn
129 56	*rtn	157 56	*rtn	185 56	*rtn	213 56	*rtn
130 56	*rtn	158 56	*rtn	186 56	*rtn	214 56	*rtn
131 56	*rtn	159 56	*rtn	187 56	*rtn	215 56	*rtn
132 56	*rtn	160 56	*rtn	188 56	*rtn	216 56	*rtn
133 56	*rtn	161 56	*rtn	189 56	*rtn	217 56	*rtn
134 56	*rtn	162 56	*rtn	190 56	*rtn	218 56	*rtn
135 56	*rtn	163 56	*rtn	191 56	*rtn	219 56	*rtn
136 56	*rtn	164 56	*rtn	192 56	*rtn	220 56	*rtn
137 56	*rtn	165 56	*rtn	193 56	*rtn	221 56	*rtn
138 56	*rtn	166 56	*rtn	194 56	*rtn	222 56	*rtn
139 56	*rtn	167 56	*rtn	195 56	*rtn	223 56	*rtn

*Denotes 2nd function key

BASE CONVERSIONS

This program will convert a decimal number, N_{10}, to N_b in a base b number system whose value agrees with that of N_{10}. The opposite conversion (from base b to base 10) can also be performed.

NOTES:
1. Base b has the possible range of $2 \leq b \leq 99$
2. The program uses the absolute value of any value entered.
3. Representation of a number in a system having a base greater than 10 uses two character positions per digit. For example: $8C7_{16} = 8\ \ 12\ \ 07$, where the 12 represents the C and the 8 is preceded by an unlit zero.
4. When an exponent appears in the display, it is always in base 10. It only serves to locate the decimal point. For example, in base 27, 3.211702 08 means $0321170200._{27}$.

Example: Convert 787_{10} to base 16.

Enter	Press	Display	Comments
787	A	787.	N_{10}
16	B	30103.	N_{16}

Example: Convert 1.123506_{50} to base 10.

Enter	Press	Display	Comments
1.123506	A	1.123506	N_{50}
50	C	1.254048	N_{10}

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MA1-20 BASE CONVERSIONS

◆A■ BASE CONVERSIONS MA1-20

N10, Nb	b→Nb	b→N10

10→B B→10

#

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
	Perform Steps 2-3 for			
	converting base 10 number			
	to some other base.			
	Perform Steps 4-5 for			
	converting some base			
	number to base 10			
2	Enter N_{10}	N_{10}	A	N_{10}
3	Enter desired base	b	B	N_b
4	Enter N_b	N_b	A	N_b
5	Enter b — Compute N_{10}	b	C	N_{10}

10→B

B→10

10 = A
11 = B
12 = C
13 = D
14 = E
15 = F

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 81	HLT	028 52	EE	056 80	*if pos	084 06	6
001 46	*LBL	029 22	INV	057 40	*x^2	085 41	GTO
002 55	÷	030 52	EE	058 43	RCL	086 20	*1/x
003 43	RCL	031 57	*fix	059 00	0	087 46	*LBL
004 00	0	032 09	9	060 03	3	088 65	×
005 02	2	033 46	*LBL	061 22	INV	089 43	RCL
006 49	*PROD	034 69	*9'	062 90	*if zro	090 00	0
007 00	0	035 44	SUM	063 55	÷	091 06	6
008 03	3	036 00	0	064 46	*LBL	092 49	*PROD
009 43	RCL	037 05	5	065 40	*x^2	093 00	0
010 00	0	038 94	+/−	066 43	RCL	094 05	5
011 01	1	039 44	SUM	067 00	0	095 01	1
012 49	*PROD	040 00	0	068 01	1	096 22	INV
013 00	0	041 03	3	069 20	*1/x	097 44	SUM
014 05	5	042 01	1	070 42	STO	098 00	0
015 43	RCL	043 94	+/−	071 00	0	099 04	4
016 00	0	044 44	SUM	072 06	6	100 46	*LBL
017 03	3	045 00	0	073 43	RCL	101 20	*1/x
018 90	*if zro	046 04	4	074 00	0	102 43	RCL
019 69	*9'	047 43	RCL	075 04	4	103 00	0
020 22	INV	048 00	0	076 22	INV	104 04	4
021 52	EE	049 05	5	077 80	*if pos	105 80	*if pos
022 75	−	050 75	−	078 20	*1/x	106 32	sin
023 93	•	051 01	1	079 43	RCL	107 94	+/−
024 05	5	052 02	2	080 00	0	108 46	*LBL
025 95	=	053 22	INV	081 01	1	109 32	sin
026 57	*fix	054 28	*log	082 42	STO	110 42	STO
027 00	0	055 95	=	083 00	0	111 00	0

*Denotes 2nd function key

REGISTERS

00	05 Number 2	10	15
01 BASE 1	06 Used	11	16
02 BASE 2	07	12	17
03 Number 1	08	13	18
04 Used	09	14	19

FLAGS

0 Used	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 04	4	140 03	3	168 33	cos	196 41	GTO
113 75	−	141 75	−	169 01	1	197 45	y^x
114 01	1	142 01	1	170 00	0	198 46	*LBL
115 95	=	143 95	=	171 00	0	199 11	A
116 80	*if pos	144 80	*if pos	172 41	GTO	200 47	*CMs
117 65	×	145 30	*$\sqrt{x}$	173 29	*x!	201 80	*if pos
118 43	RCL	146 41	GTO	174 46	*LBL	202 34	tan
119 00	0	147 55	÷	175 33	cos	203 94	+/−
120 05	5	148 46	*LBL	176 01	1	204 46	*LBL
121 47	*CMs	149 13	C	177 00	0	205 34	tan
122 86	*rset	150 50	*st flg	178 46	*LBL	206 42	STO
123 46	*LBL	151 00	0	179 29	*x!	207 00	0
124 30	*$\sqrt{x}$	152 46	*LBL	180 42	STO	208 03	3
125 43	RCL	153 12	B	181 00	0	209 56	*rtn
126 00	0	154 80	*if pos	182 01	1	210 00	
127 02	2	155 44	SUM	183 22	INV	211 00	
128 22	INV	156 94	+/−	184 60	*if flg	212 00	
129 49	*PROD	157 46	*LBL	185 00	0	213 00	
130 00	0	158 44	SUM	186 45	y^x	214 00	
131 03	3	159 42	STO	187 43	RCL	215 00	
132 01	1	160 00	0	188 00	0	216 00	
133 44	SUM	161 02	2	189 01	1	217 00	
134 00	0	162 94	+/−	190 48	*EXC	218 00	
135 04	4	163 85	+	191 00	0	219 00	
136 46	*LBL	164 01	1	192 02	2	220 00	
137 45	y^x	165 00	0	193 42	STO	221 00	
138 43	RCL	166 95	=	194 00	0	222 00	
139 00	0	167 80	*if pos	195 01	1	223 00	

*Denotes 2nd function key

PRIME FACTORS OF AN INTEGER

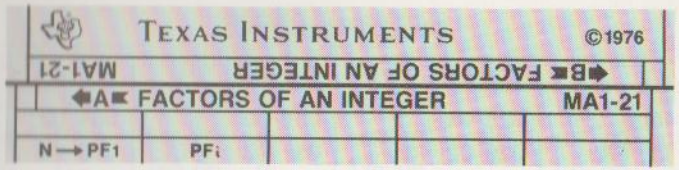
Given integer N, this program determines all PF_i where these are the prime factors of N and

$$N = \text{II } PF_i$$

After entering N from the keyboard, pressing [A] causes the smallest PF_i to appear on the display. Each additional PF_i is obtained by pressing [B]. A flashing 1 on the display indicates that there are no more prime factors. If a negative N is entered, the above procedure is followed; however, the display flashes. The largest acceptable N is ten digits. If $|N| < 2$, N appears on the display after pressing [A] and a flashing 1 after pressing [B].

Example:

Enter	Press	Display	Comments
39270		39270	N
	[A]	2.	PF_1
	[B]	3.	PF_2
	[B]	5.	PF_3
	[B]	7.	PF_4
	[B]	11.	PF_5
	[B]	17.	PF_6
	[B]	1. flashing	End of program



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Obtain least factor	N	[A]	PF_1
3	Obtain next factor		[B]	PF_2
4	Repeat Step 3 to obtain		[B]	PF_3, etc.
	remaining factors, until		[B]	PF_i
	flashing 1 appears		[B]	Flashing 1

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 01	1	056 55	÷	084 02	2
001 11	A	029 02	2	057 43	RCL	085 44	SUM
002 22	INV	030 42	STO	058 00	0	086 00	0
003 52	EE	031 00	0	059 02	2	087 01	1
004 98	*prt	032 02	2	060 95	=	088 60	*if flg
005 99	*pap	033 46	*LBL	061 15	E	089 01	1
006 42	STO	034 12	B	062 65	×	090 44	SUM
007 00	0	035 60	*if flg	063 43	RCL	091 02	2
008 00	0	036 02	2	064 00	0	092 44	SUM
009 80	*if pos	037 87	*1′	065 02	2	093 00	0
010 78	*5′	038 43	RCL	066 75	−	094 01	1
011 25	CLR	039 00	0	067 43	RCL	095 50	*st flg
012 20	*1/x	040 00	0	068 00	0	096 01	1
013 43	RCL	041 55	÷	069 00	0	097 46	*LBL
014 00	0	042 43	RCL	070 95	=	098 36	*IND
015 00	0	043 00	0	071 90	*if zro	099 43	RCL
016 94	+/−	044 02	2	072 48	*EXC	100 00	0
017 42	STO	045 75	−	073 43	RCL	101 01	1
018 00	0	046 43	RCL	074 00	0	102 42	STO
019 00	0	047 00	0	075 02	2	103 00	0
020 46	*LBL	048 02	2	076 75	−	104 02	2
021 78	*5′	049 95	=	077 06	6	105 41	GTO
022 22	INV	050 22	INV	078 95	=	106 12	B
023 50	*st flg	051 80	*if pos	079 22	INV	107 46	*LBL
024 02	2	052 43	RCL	080 80	*if pos	108 47	*CMs
025 01	1	053 43	RCL	081 47	*CMs	109 50	*st flg
026 42	STO	054 00	0	082 46	*LBL	110 01	1
027 00	0	055 00	0	083 49	*PROD	111 41	GTO

*Denotes 2nd function key

REGISTERS

00 Integer	05	10	15
01 Used	06	11	16
02 Used	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1 Used	2 Used	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 49	*PROD	140 43	RCL	168 00		196 00	
113 46	*LBL	141 00	0	169 00		197 00	
114 87	*1′	142 00	0	170 00		198 00	
115 00	0	143 50	*st flg	171 00		199 00	
116 20	*1/x	144 02	2	172 00		200 00	
117 01	1	145 98	*prt	173 00		201 00	
118 99	*pap	146 56	*rtn	174 00		202 00	
119 56	*rtn	147 46	*LBL	175 00		203 00	
120 46	*LBL	148 15	E	176 00		204 00	
121 44	SUM	149 75	−	177 00		205 00	
122 22	INV	150 93	•	178 00		206 00	
123 50	*st flg	151 05	5	179 00		207 00	
124 01	1	152 95	=	180 00		208 00	
125 41	GTO	153 57	*fix	181 00		209 00	
126 36	*IND	154 00	0	182 00		210 00	
127 46	*LBL	155 95	=	183 00		211 00	
128 48	*EXC	156 52	EE	184 00		212 00	
129 43	RCL	157 22	INV	185 00		213 00	
130 00	0	158 52	EE	186 00		214 00	
131 02	2	159 57	*fix	187 00		215 00	
132 22	INV	160 09	9	188 00		216 00	
133 49	*PROD	161 56	*rtn	189 00		217 00	
134 00	0	162 00		190 00		218 00	
135 00	0	163 00		191 00		219 00	
136 98	*prt	164 00		192 00		220 00	
137 56	*rtn	165 00		193 00		221 00	
138 46	*LBL	166 00		194 00		222 00	
139 43	RCL	167 00		195 00		223 00	

*Denotes 2nd function key

GREATEST COMMON DIVISOR LEAST COMMON MULTIPLE

This program can be used to find the greatest common divisor (GCD) and the least common multiple (LCM) of integers U_1 and U_2. $U_1 \neq 0, U_2 \neq 0$.

$$LCM = \frac{U_1 \times U_2}{GCD\ (U_1 \times U_2)}$$

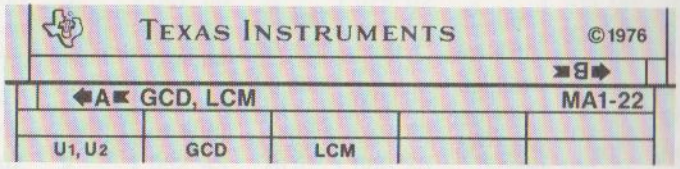
Error conditions: 0 will flash if either $U_1 = 0$ or $U_2 = 0$.

Reference: *The Art of Computer Programming*, D. E. Knuth, Addison-Wesley, 1969.

Example: Find the GCD and the LCM of 480 and 1024.

Enter	Press	Display	Comments
480	A	480.	
1024	RUN	1024.	
	B	32.	GCD
	C	15360.	LCM

Example: $U_1 = 480, U_2 = 1024$
GCD (480, 1024) = 32
LCM (480, 1024) = 15360



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A only)			
2	Enter U_1	U_1	A	U_1
3	Enter U_2	U_2	RUN	U_2
4	Calculate GCD		B	GCD
5	Calculate LCM		C	LCM

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 12	B	056 46	*LBL	084 02	2
001 32	sin	029 43	RCL	057 11	A	085 56	*rtn
002 75	−	030 00	0	058 90	*if zro	086 46	*LBL
003 43	RCL	031 01	1	059 87	*1′	087 87	*1′
004 00	0	032 42	STO	060 42	STO	088 20	*1/x
005 00	0	033 00	0	061 00	0	089 00	0
006 95	=	034 00	0	062 01	1	090 56	*rtn
007 90	*if zro	035 43	RCL	063 80	*if pos	091 00	
008 33	cos	036 00	0	064 88	*2′	092 00	
009 80	*if pos	037 02	2	065 94	+/−	093 00	
010 32	sin	038 41	GTO	066 46	*LBL	094 00	
011 85	+	039 32	sin	067 88	*2′	095 00	
012 43	RCL	040 46	*LBL	068 48	*EXC	096 00	
013 00	0	041 13	C	069 00	0	097 00	
014 00	0	042 12	B	070 01	1	098 00	
015 95	=	043 43	RCL	071 56	*rtn	099 00	
016 48	*EXC	044 00	0	072 90	*if zro	100 00	
017 00	0	045 01	1	073 87	*1′	101 00	
018 00	0	046 55	÷	074 42	STO	102 00	
019 41	GTO	047 43	RCL	075 00	0	103 00	
020 32	sin	048 00	0	076 02	2	104 00	
021 46	*LBL	049 00	0	077 80	*if pos	105 00	
022 33	cos	050 65	×	078 89	*3′	106 00	
023 43	RCL	051 43	RCL	079 94	+/−	107 00	
024 00	0	052 00	0	080 46	*LBL	108 00	
025 00	0	053 02	2	081 89	*3′	109 00	
026 56	*rtn	054 95	=	082 48	*EXC	110 00	
027 46	*LBL	055 56	*rtn	083 00	0	111 00	

*Denotes 2nd function key

REGISTERS

00 Used	05	10	15
01 U_1	06	11	16
02 U_2	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1	2	3	4

ARITHMETIC AND HARMONIC PROGRESSIONS

An arithmetic progression has the form I_1, $I_1 + d$, $I_1 + 2d$, $I_1 + 3d$, ..., $I_1 + (n - 1)d$. This program may be used to find the following:

1. Describe each term of the arithmetic progression: $I_1, I_2, I_3 \ldots$
2. The n^{th} term I_n of the progression $I_n = I_1 + (n - 1)d$
3. The sum of the first n terms of an arithmetic progression:

   a. $S_n(I_n) = \frac{n}{2}(I_1 + I_n)$, given n, I_1, I_n or

   b. $S_n(d) = \frac{n}{2}[2I_1 + (n-1)d]$, given n, I_1, d

where: I_1 = first term d = common difference
I_n = last term n = number of terms

A harmonic progression is a sequence whose termwise reciprocals form an arithmetic progression. It has the form:

$\frac{a}{b}, \frac{a}{b+c}, \frac{a}{b+2c}$, etc.

4. The x^{th} term of a harmonic progression

$$h_x = \frac{a}{b + (x-1)c}, \text{ where } b + (x-1)c \neq 0$$

5. Each term of the harmonic progression described by

$$h_i = \frac{a}{b + (i-1)c}, \text{ where } i = 1, 2, \ldots\ b + (i-1)c \neq 0$$

Reference: *Standard Mathematical Tables*, Chemical Rubber Publishing Company, Cleveland, Ohio, 1960.

Example: Describe the arithmetic progression of a series that starts at 3 and increments by 12.

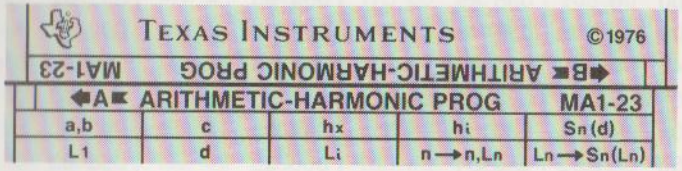
Enter	Press	Display	Comments
3	A	3.	I_1
12	B	12.	d
	C	3.	I_1
	C	15.	I_2
	C	27.	I_3
	C	39.	I_4

Example: Find the sum of the first 7 terms of an arithmetic progression with the first term being 2 with an increment of 4.

Enter	Press	Display	Comments
2	A	2.	I_1
4	B	4.	d
7	D	7.	n
	2nd E'	98.	S_n

Example: Find the 16th term of the harmonic progression 1/3, 1/8, 1/13,... Note that a = 1, b = 3, c = 5.

Enter	Press	Display	Comments
1	2nd A'	1.	a
3	RUN	3.	b
5	2nd B'	5.	c
16	2nd C'	.0128205128	h_x



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
	For Arithmetic Progressions			
	use Steps 2-8.			
	For Harmonic Progressions			
	use Steps 9-13.			
2	Enter first term	I_1	A	I_1
3	Enter difference	d	B	d
4	Calculate I_i, i = 1,2,3...		C	I_i
5	Enter number of terms	n	D	n
6	Calculate n^{th} term		RUN	I_n
7	Calculate $S_n(I_n)$	I_n	E	S_n
8	Calculate $S_n(d)$		2nd E'	S_n
9	Enter a	a	2nd A'	a
10	Enter b	b	RUN	b
11	Enter c	c	2nd B'	c
12	Calculate x^{th} term	x	2nd C'	h_x
13	Calculate h_i, i = 1,2,3...		2nd D'	h_i
	(if x has been entered,			
	i = x + 1, x + 2, x + 3,...)			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 65	×	056 56	*rtn	084 01	1
001 11	A	029 53	(	057 46	*LBL	085 95	=
002 48	*EXC	030 43	RCL	058 15	E	086 65	×
003 00	0	031 00	0	059 85	+	087 43	RCL
004 00	0	032 00	0	060 43	RCL	088 00	0
005 01	1	033 75	−	061 00	0	089 03	3
006 48	*EXC	034 01	1	062 01	1	090 55	÷
007 00	0	035 95	=	063 95	=	091 02	2
008 00	0	036 48	*EXC	064 65	×	092 95	=
009 42	STO	037 00	0	065 43	RCL	093 56	*rtn
010 00	0	038 00	0	066 00	0	094 00	
011 01	1	039 85	+	067 03	3	095 00	
012 56	*rtn	040 01	1	068 55	÷	096 00	
013 46	*LBL	041 95	=	069 02	2	097 00	
014 12	B	042 48	*EXC	070 95	=	098 00	
015 42	STO	043 00	0	071 56	*rtn	099 00	
016 00	0	044 00	0	072 46	*LBL	100 00	
017 02	2	045 56	*rtn	073 10	*E'	101 00	
018 56	*rtn	046 46	*LBL	074 43	RCL	102 00	
019 46	*LBL	047 14	D	075 00	0	103 00	
020 13	C	048 42	STO	076 03	3	104 00	
021 43	RCL	049 00	0	077 42	STO	105 00	
022 00	0	050 00	0	078 00	0	106 00	
023 01	1	051 42	STO	079 00	0	107 00	
024 85	+	052 00	0	080 13	C	108 00	
025 43	RCL	053 03	3	081 85	+	109 00	
026 00	0	054 56	*rtn	082 43	RCL	110 00	
027 02	2	055 13	C	083 00	0	111 00	

*Denotes 2nd function key

REGISTERS

00 Used	05 Used	10	15
01 Used	06 Used	11	16
02 Used	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 46	*LBL	140 23	Inx	168 54	)	196 00	
113 16	*A'	141 43	RCL	169 85	+	197 00	
114 48	*EXC	142 00	0	170 43	RCL	198 00	
115 00	0	143 06	6	171 00	0	199 00	
116 06	6	144 70	*if err	172 04	4	200 00	
117 01	1	145 34	tan	173 95	=	201 00	
118 48	*EXC	146 51	SBR	174 20	*1/x	202 00	
119 00	0	147 33	cos	175 65	×	203 00	
120 06	6	148 46	*LBL	176 43	RCL	204 00	
121 42	STO	149 34	tan	177 00	0	205 00	
122 00	0	150 56	*rtn	178 03	3	206 00	
123 03	3	151 46	*LBL	179 95	=	207 00	
124 56	*rtn	152 19	*D'	180 48	*EXC	208 00	
125 42	STO	153 51	SBR	181 00	0	209 00	
126 00	0	154 33	cos	182 06	6	210 00	
127 04	4	155 56	*rtn	183 85	+	211 00	
128 56	*rtn	156 46	*LBL	184 01	1	212 00	
129 46	*LBL	157 33	cos	185 95	=	213 00	
130 17	*B'	158 43	RCL	186 48	*EXC	214 00	
131 42	STO	159 00	0	187 00	0	215 00	
132 00	0	160 05	5	188 06	6	216 00	
133 05	5	161 65	×	189 56	*rtn	217 00	
134 56	*rtn	162 53	(	190 00		218 00	
135 46	*LBL	163 43	RCL	191 00		219 00	
136 18	*C'	164 00	0	192 00		220 00	
137 42	STO	165 06	6	193 00		221 00	
138 00	0	166 75	−	194 00		222 00	
139 06	6	167 01	1	195 00		223 00	

*Denotes 2nd function key

GEOMETRIC PROGRESSION

A geometric progression has the form a, ar, ar^2, $ar^3 \ldots ar^{i-1}$. This program may be used to find the following:

1. The geometric progression $l_i = ar^{i-1}$, $(i = 1, 2, 3 \ldots)$
2. The n^{th} term of the progression $l_n = ar^{n-1} (n = 1, 2, 3 \ldots)$
3. The sum S_n of the first n terms of the progression

$$S_n = a\left(\frac{r^n - 1}{r - 1}\right)$$

4. The infinite sum S_∞ of the progression.

$$S_\infty = \frac{a}{1 - r}, r^2 < 1$$

where: a = first term
r = common ratio
n = number of terms (n = 1, 2, 3, ...)

Error conditions:
1. $n \leq 1$
2. $r^2 \geqslant 1$ for S_∞ calculation

Example: Describe the geometric progression for $(4)(3)^{i-1}$, $i = 1, 2, 3 \ldots$

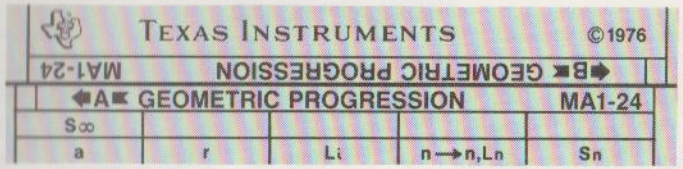
Enter	Press	Display	Comments
4	A	4.	a
3	B	3.	r
	C	4.	l_1
	C	12.	l_2
	C	36.	l_3
	C	108.	l_4

Example: Find the 18^{th} term of $(2)(-1.5)^{n-1}$

Enter	Press	Display	Comments
2	A	2.	a
1.5	+/− B	−1.5	r
18	D	18.	n
	RUN	−1970.522507	l_{18}

Example: Find the sum of the first 8 terms of 4^{n-1}

Enter	Press	Display	Comments
1	A	1.	a
4	B	4.	r
8	D	8.	n
	E	21845.	Sn



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Enter a	a	A	a
3	Enter r	r	B	r
4	Perform 4 for i = 1,2,...		C	l_i
5	Enter n	n	D	n
6	Calculate l_n, given a,r,n		RUN	l_n
7	Calculate S_n, given a,r,n		E	S_n
8	Calculate S_∞, given a,r		2nd A'	S_∞

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 00	0	056 00	0	084 43	RCL
001 11	A	029 01	1	057 00	0	085 00	0
002 42	STO	030 45	y^x	058 42	STO	086 04	4
003 00	0	031 43	RCL	059 00	0	087 94	+/−
004 00	0	032 00	0	060 03	3	088 56	*rtn
005 50	*st flg	033 03	3	061 43	RCL	089 46	*LBL
006 00	0	034 65	×	062 00	0	090 44	SUM
007 56	*rtn	035 43	RCL	063 00	0	091 43	RCL
008 46	*LBL	036 00	0	064 56	*rtn	092 00	0
009 12	B	037 00	0	065 46	*LBL	093 03	3
010 42	STO	038 95	=	066 33	cos	094 55	÷
011 00	0	039 46	*LBL	067 43	RCL	095 02	2
012 01	1	040 65	×	068 00	0	096 95	=
013 50	*st flg	041 42	STO	069 01	1	097 17	*B′
014 00	0	042 00	0	070 80	*if pos	098 65	×
015 56	*rtn	043 04	4	071 52	EE	099 02	2
016 46	*LBL	044 70	*if err	072 25	CLR	100 95	=
017 13	C	045 33	cos	073 43	RCL	101 75	−
018 60	*if flg	046 46	*LBL	074 00	0	102 43	RCL
019 00	0	047 52	EE	075 03	3	103 00	0
020 34	tan	048 43	RCL	076 75	−	104 03	3
021 01	1	049 00	0	077 01	1	105 95	=
022 44	SUM	050 04	4	078 95	=	106 90	*if zro
023 00	0	051 56	*rtn	079 22	INV	107 52	EE
024 03	3	052 46	*LBL	080 90	*if zro	108 41	GTO
025 46	*LBL	053 34	tan	081 44	SUM	109 43	RCL
026 32	sin	054 22	INV	082 46	*LBL	110 46	*LBL
027 43	RCL	055 50	*st flg	083 43	RCL	111 17	*B′

*Denotes 2nd function key

REGISTERS

00 a	05	10	15
01 r	06	11	16
02 n	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0 Used	1	2	3	4

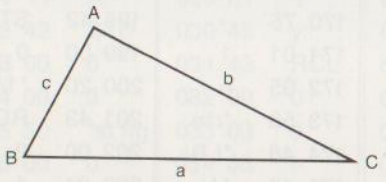
PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 22	INV	140 03	3	168 00	0	196 56	*rtn
113 52	EE	141 41	GTO	169 01	1	197 46	*LBL
114 75	−	142 32	sin	170 75	−	198 42	STO
115 93	•	143 46	*LBL	171 01	1	199 00	0
116 05	5	144 15	E	172 95	=	200 20	*1/x
117 95	=	145 43	RCL	173 56	*rtn	201 43	RCL
118 57	*fix	146 00	0	174 46	*LBL	202 00	0
119 00	0	147 01	1	175 16	*A′	203 01	1
120 52	EE	148 45	y^x	176 43	RCL	204 56	*rtn
121 22	INV	149 43	RCL	177 00	0	205 00	
122 52	EE	150 00	0	178 01	1	206 00	
123 57	*fix	151 02	2	179 40	*x^2	207 00	
124 09	9	152 42	STO	180 75	−	208 00	
125 56	*rtn	153 00	0	181 01	1	209 00	
126 46	*LBL	154 03	3	182 95	=	210 00	
127 14	D	155 95	=	183 80	*if pos	211 00	
128 42	STO	156 51	SBR	184 42	STO	212 00	
129 00	0	157 65	×	185 43	RCL	213 00	
130 02	2	158 75	−	186 00	0	214 00	
131 56	*rtn	159 01	1	187 00	0	215 00	
132 43	RCL	160 95	=	188 55	÷	216 00	
133 00	0	161 65	×	189 53	(	217 00	
134 02	2	162 43	RCL	190 01	1	218 00	
135 75	−	163 00	0	191 75	−	219 00	
136 01	1	164 00	0	192 43	RCL	220 00	
137 95	=	165 55	÷	193 00	0	221 00	
138 42	STO	166 53	(	194 01	1	222 00	
139 00	0	167 43	RCL	195 95	=	223 00	

*Denotes 2nd function key

TRIANGLE SOLUTION (1)

Knowing a certain combination of attributes (angles or side lengths) of a triangle, the unknown attributes can be calculated.



$$A + B + C = 180°$$

$$c = \sqrt{a^2 + b^2 - 2ab\cos C}$$

This program will perform the following:

Knowing SSS (sides a, b, c), compute angles A, B, C

Knowing SSA (sides a, b, angle A), compute angles B, C, side c

Knowing SAS (sides a, b, angle C), compute angles A, B, side c

See program TRIANGLE SOLUTION (2) MA1-26 for more combinations.

NOTES: 1. All angles should be submitted in the same units, either degrees or radians.
2. Once all the sides have been determined, they are stored in the proper registers ($R_{00} - R_{02}$) for calculation of area by MA1-26.
3. The resulting solution to a particular problem may not be that problem's unique solution.
4. A flashing display indicates that there is no triangle satisfying the entered values.

Example: Given a = 4.1, b = 2.7, c = 1.6, calculate the angles.

Angle = degrees

Enter	Press	Display	Comments
4.1	A	4.1	a
2.7	B	2.7	b
1.6	C	1.6	c
	2nd A'	143.6639425	∠A
	D	22.96671197	∠B
	E	13.36934555	∠C

Example: Given a = 38.4, b = 16.8, ∠A = 42°, calculate c, ∠B, ∠C

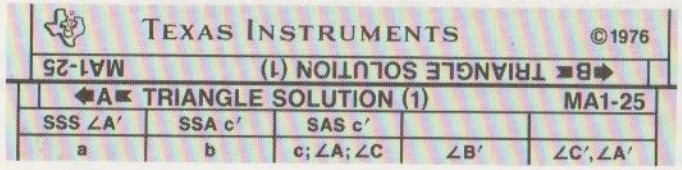
Angle = degrees

Enter	Press	Display	Comments
38.4	A	38.4	a
16.8	B	16.8	b
42	C	42	∠A
	2nd B'	49.20255436	c
	D	17.02234529	∠B
	E	120.9776547	∠C

Example: Given a = 2, b = $\sqrt{3}$, ∠C = .5235987756 radians, calculate c, ∠B, ∠A

Angle = radians

Enter	Press	Display	Comments
2	A	2.	a
3	2nd √x B	1.732050808	b
.5235987756	C	.5235987756	∠C
	2nd C'	1.	c
	D	1.047197551	∠B
	E	1.570796327	∠A



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
	Knowing SSS					
2	Enter a	a	A			a
3	Enter b	b	B			b
4	Enter c	c	C			c
5	Calculate ∠A		2nd	A′		∠A
6	Calculate ∠B		D			∠B
7	Calculate ∠C		E			∠C
	Knowing SSA					
8	Enter a	a	A			a
9	Enter b	b	B			b
10	Enter ∠A	∠A	C			∠A
11	Calculate c		2nd	B′		c
12	Calculate ∠B		D			∠B
13	Calculate ∠C		E			∠C
	Knowing SAS					
14	Enter a	a	A			a
15	Enter b	b	B			b
16	Enter ∠C	∠C	C			∠C
17	Calculate c		2nd	C′		c
18	Calculate ∠B		D			∠B
19	Calculate ∠A		E			∠A

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 81	HLT	028 55	÷	056 00	0	084 79	*6′
001 46	*LBL	029 43	RCL	057 00	0	085 86	*rset
002 10	*E′	030 00	0	058 12	B	086 46	*LBL
003 43	RCL	031 01	1	059 43	RCL	087 11	A
004 00	0	032 95	=	060 00	0	088 42	STO
005 02	2	033 22	INV	061 06	6	089 00	0
006 56	*rtn	034 33	cos	062 11	A	090 00	0
007 46	*LBL	035 60	*if flg	063 41	GTO	091 56	*rtn
008 16	*A′	036 02	2	064 16	*A′	092 46	*LBL
009 43	RCL	037 69	*9′	065 46	*LBL	093 12	B
010 00	0	038 42	STO	066 69	*9′	094 42	STO
011 00	0	039 00	0	067 60	*if flg	095 00	0
012 40	*x^2	040 05	5	068 03	3	096 01	1
013 85	+	041 50	*st flg	069 68	*8′	097 56	*rtn
014 43	RCL	042 02	2	070 42	STO	098 46	*LBL
015 00	0	043 46	*LBL	071 00	0	099 13	C
016 01	1	044 67	*7′	072 04	4	100 42	STO
017 40	*x^2	045 43	RCL	073 50	*st flg	101 00	0
018 75	−	046 00	0	074 03	3	102 02	2
019 10	*E′	047 02	2	075 41	GTO	103 56	*rtn
020 40	*x^2	048 42	STO	076 67	*7′	104 46	*LBL
021 95	=	049 00	0	077 46	*LBL	105 18	*C′
022 55	÷	050 06	6	078 68	*8′	106 43	RCL
023 02	2	051 43	RCL	079 42	STO	107 00	0
024 55	÷	052 00	0	080 00	0	108 00	0
025 43	RCL	053 01	1	081 03	3	109 40	*x^2
026 00	0	054 13	C	082 60	*if flg	110 85	+
027 00	0	055 43	RCL	083 00	0	111 43	RCL

REGISTERS

00 a	05 Used	10	15
01 b	06 Used	11	16
02 c	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0 Used	1 Used	2 Used	3 Used	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 00	0	140 41	GTO	168 52	EE	196 46	*LBL
113 01	1	141 67	*7′	169 22	INV	197 78	*5′
114 40	*x^2	142 46	*LBL	170 32	sin	198 42	STO
115 75	−	143 79	*6′	171 52	EE	199 00	0
116 02	2	144 42	STO	172 22	INV	200 02	2
117 65	×	145 00	0	173 52	EE	201 86	*rset
118 43	RCL	146 05	5	174 42	STO	202 46	*LBL
119 00	0	147 43	RCL	175 00	0	203 14	D
120 00	0	148 00	0	176 04	4	204 43	RCL
121 65	×	149 01	1	177 94	+/−	205 00	0
122 43	RCL	150 86	*rset	178 85	+	206 04	4
123 00	0	151 46	*LBL	179 01	1	207 56	*rtn
124 01	1	152 17	*B′	180 94	+/−	208 46	*LBL
125 65	×	153 10	*E′	181 22	INV	209 15	E
126 10	*E′	154 32	sin	182 33	cos	210 43	RCL
127 33	cos	155 65	×	183 75	−	211 00	0
128 95	=	156 43	RCL	184 10	*E′	212 05	5
129 30	*$\sqrt{x}$	157 00	0	185 95	=	213 56	*rtn
130 60	*if flg	158 01	1	186 42	STO	214 00	
131 01	1	159 55	÷	187 00	0	215 00	
132 78	*5′	160 43	RCL	188 02	2	216 00	
133 42	STO	161 00	0	189 42	STO	217 00	
134 00	0	162 00	0	190 00	0	218 00	
135 02	2	163 95	=	191 05	5	219 00	
136 50	*st flg	164 22	INV	192 50	*st flg	220 00	
137 02	2	165 52	EE	193 01	1	221 00	
138 50	*st flg	166 52	EE	194 41	GTO	222 00	
139 00	0	167 22	INV	195 18	*C′	223 00	

TRIANGLE SOLUTION (2)

A continuation of MA1-25, TRIANGLE SOLUTION (1), this program will compute the following:

Knowing ASA (angles B, C, side a), compute b, c, ∠A

Knowing SAA (side a, angles A, C), compute b, c, ∠B

The area of any triangle input to either this program or MA1-25

$$\text{Area of } \Delta = \sqrt{s(s-a)(s-b)(s-c)},\ s = \frac{a+b+c}{2}$$

NOTES: 1. All angles should be submitted in the same units, either degrees or radians.
2. The sum of the inputted angles must be less than 180° or π radians.

Example: Given a = 15, ∠B = 74.2°, ∠C = 31.6°, calculate b, c, ∠A.

Angle = degrees

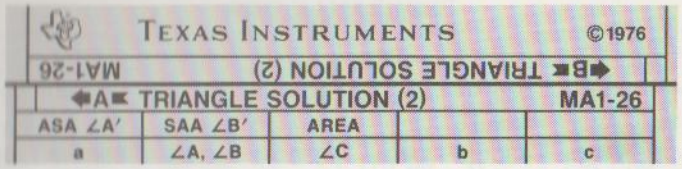
Enter	Press	Display	Comments
15	A	15.	a
74.2	B	74.2	∠B
31.6	C	31.6	∠C
	2nd A'	74.2	∠A
	D	15.	b
	E	8.168407411	c

Example: Given a = 26.6, ∠A = 50.2°, ∠C = 95.4°, compute the area.

Angle = degrees

Enter	Press	Display	Comments
26.6	A	26.6	a
50.2	B	50.2	∠A
95.4	C	95.4	∠C
	2nd B'	34.4	∠B
	D	19.56064634	b
	E	34.4689785	c
	2nd C'	259.0020121	Area

Example: Compute the area of the triangle evaluated in the first example of MA1-25. After all sides have been entered (or calculated as the case may be) they are automatically stored in R_{00}-R_{02}. Now load MA1-26 and press 2nd C', the area is 1.27984374.



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
	Knowing ASA			
2	Enter a	a	A	a
3	Enter ∠B	∠B	B	∠B
4	Enter ∠C	∠C	C	∠C
5	Calculate ∠A		2nd A'	∠A
6	Calculate b		D	b
7	Calculate c		E	c
	Knowing SAA			
8	Enter a	a	A	a
9	Enter ∠A	∠A	B	∠A
10	Enter ∠C	∠C	C	∠C
11	Calculate ∠B		2nd B'	∠B
12	Calculate b		D	b
13	Calculate c		E	c
14	Calculate area of Δ.		2nd C'	Area
	a,b,c must have been			
	previously computed and			
	consequently reside in			
	R_{00} – R_{02}. If not they can			
	be manually placed there.			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 04	4	056 05	5	084 00	0
001 11	A	029 75	−	057 95	=	085 65	×
002 42	STO	030 43	RCL	058 42	STO	086 43	RCL
003 00	0	031 00	0	059 00	0	087 00	0
004 00	0	032 05	5	060 04	4	088 05	5
005 56	*rtn	033 95	=	061 50	*st flg	089 32	sin
006 46	*LBL	034 42	STO	062 00	0	090 55	÷
007 12	B	035 00	0	063 46	*LBL	091 43	RCL
008 42	STO	036 03	3	064 85	+	092 00	0
009 00	0	037 41	GTO	065 43	RCL	093 03	3
010 04	4	038 85	+	066 00	0	094 32	sin
011 56	*rtn	039 46	*LBL	067 00	0	095 95	=
012 46	*LBL	040 17	*B′	068 65	×	096 42	STO
013 13	C	041 25	CLR	069 43	RCL	097 00	0
014 42	STO	042 01	1	070 00	0	098 02	2
015 00	0	043 94	+/−	071 04	4	099 60	*if flg
016 05	5	044 22	INV	072 32	sin	100 00	0
017 56	*rtn	045 33	cos	073 55	÷	101 65	×
018 46	*LBL	046 75	−	074 43	RCL	102 43	RCL
019 16	*A′	047 43	RCL	075 00	0	103 00	0
020 25	CLR	048 00	0	076 03	3	104 03	3
021 01	1	049 04	4	077 32	sin	105 56	*rtn
022 94	+/−	050 42	STO	078 95	=	106 46	*LBL
023 22	INV	051 00	0	079 42	STO	107 65	×
024 33	cos	052 03	3	080 00	0	108 43	RCL
025 75	−	053 75	−	081 01	1	109 00	0
026 43	RCL	054 43	RCL	082 43	RCL	110 04	4
027 00	0	055 00	0	083 00	0	111 22	INV

REGISTERS

00 a	05 Used	10	15
01 b	06 Used	11	16
02 c	07	12	17
03 Used	08	13	18
04 Used	09	14	19

FLAGS

0 Used	1	2	3	4

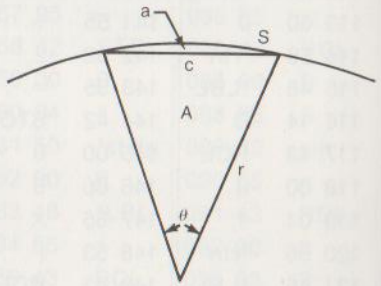
PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 50	*st flg	140 95	=	168 53	(	196 00	
113 00	0	141 55	÷	169 43	RCL	197 00	
114 56	*rtn	142 02	2	170 00	0	198 00	
115 46	*LBL	143 95	=	171 06	6	199 00	
116 14	D	144 42	STO	172 75	−	200 00	
117 43	RCL	145 00	0	173 43	RCL	201 00	
118 00	0	146 06	6	174 00	0	202 00	
119 01	1	147 65	×	175 02	2	203 00	
120 56	*rtn	148 53	(	176 95	=	204 00	
121 46	*LBL	149 43	RCL	177 30	*$\sqrt{x}$	205 00	
122 15	E	150 00	0	178 56	*rtn	206 00	
123 43	RCL	151 06	6	179 00		207 00	
124 00	0	152 75	−	180 00		208 00	
125 02	2	153 43	RCL	181 00		209 00	
126 56	*rtn	154 00	0	182 00		210 00	
127 46	*LBL	155 00	0	183 00		211 00	
128 18	*C′	156 95	=	184 00		212 00	
129 43	RCL	157 65	×	185 00		213 00	
130 00	0	158 53	(	186 00		214 00	
131 00	0	159 43	RCL	187 00		215 00	
132 85	+	160 00	0	188 00		216 00	
133 43	RCL	161 06	6	189 00		217 00	
134 00	0	162 75	−	190 00		218 00	
135 01	1	163 43	RCL	191 00		219 00	
136 85	+	164 00	0	192 00		220 00	
137 43	RCL	165 01	1	193 00		221 00	
138 00	0	166 95	=	194 00		222 00	
139 02	2	167 65	×	195 00		223 00	

CURVE SOLUTION

This program can be used to calculate the following:

Central angle, θ ($<\pi$)
Circle radius, r
Arc length, $s = r\theta$
Chord length, $c = 2r \sin\left(\frac{\theta}{2}\right)$
Sector area, $A = \frac{sr}{2}$
Segment area, $a = \frac{sr}{2} - \left(\frac{cr}{2}\right) \cos\frac{\theta}{2}$



Knowing certain pairs of θ, r, s, or c the other information can be calculated.

Reference: *Standard Math Tables*, Chemical Rubber Publishing Company, 1960.

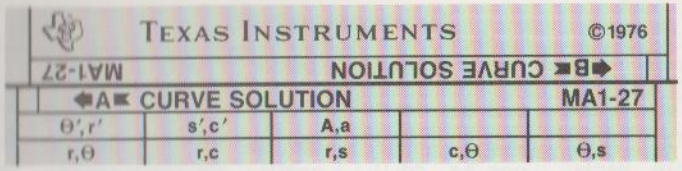
Angle = radians

Example: $r = 2$, $\theta = .5$

Enter	Press	Display	Comments
2	A	2.	r
.5	RUN	1.	s
	2nd B'	1.	s
	RUN	0.989615837	c
	2nd C'	1.	A
	RUN	.0411489228	a

Example: $c = 2$, $\theta = .1$

Enter	Press	Display	Comments
2	D	2.	c
.1	RUN	2.000833576	s
	2nd A'	0.1	θ
	RUN	20.00833576	r
	2nd C'	20.016675	A
	RUN	.0333444487	a



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Set R/D switch to R					
3	Enter r	r	A			r
4	Enter θ	θ	RUN			s
OR						
3a	Enter r	r	B			r
4a	Enter c	c	RUN			s
OR						
3b	Enter r	r	C			r
4b	Enter s	s	RUN			c
OR						
3c	Enter c	c	D			c
4c	Enter θ	θ	RUN			s
OR						
3d	Enter θ	θ	E			θ
4d	Enter s	s	RUN			c
5	Calculate θ and		2nd	A'		θ
	r		RUN			r
6	Calculate s and		2nd	B'		s
	c		RUN			c
7	Calculate A and		2nd	C'		A
	a		RUN			a

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 95	=	056 32	sin	084 42	STO
001 11	A	029 32	sin	057 65	×	085 00	0
002 10	*E′	030 65	×	058 02	2	086 03	3
003 56	*rtn	031 02	2	059 95	=	087 56	*rtn
004 19	*D′	032 65	×	060 42	STO	088 19	*D′
005 51	SBR	033 43	RCL	061 00	0	089 55	÷
006 52	EE	034 00	0	062 00	0	090 02	2
007 46	*LBL	035 01	1	063 41	GTO	091 95	=
008 24	CE	036 95	=	064 24	CE	092 32	sin
009 43	RCL	037 42	STO	065 46	*LBL	093 20	*1/x
010 00	0	038 00	0	066 13	C	094 65	×
011 00	0	039 03	3	067 10	*E′	095 43	RCL
012 65	×	040 56	*rtn	068 56	*rtn	096 00	0
013 43	RCL	041 46	*LBL	069 42	STO	097 03	3
014 00	0	042 12	B	070 00	0	098 55	÷
015 01	1	043 10	*E′	071 02	2	099 02	2
016 95	=	044 56	*rtn	072 55	÷	100 95	=
017 42	STO	045 42	STO	073 43	RCL	101 42	STO
018 00	0	046 00	0	074 00	0	102 00	0
019 02	2	047 03	3	075 01	1	103 01	1
020 56	*rtn	048 55	÷	076 95	=	104 41	GTO
021 46	*LBL	049 02	2	077 42	STO	105 24	CE
022 52	EE	050 55	÷	078 00	0	106 46	*LBL
023 43	RCL	051 43	RCL	079 00	0	107 15	E
024 00	0	052 00	0	080 41	GTO	108 19	*D′
025 00	0	053 01	1	081 52	EE	109 56	*rtn
026 55	÷	054 95	=	082 46	*LBL	110 42	STO
027 02	2	055 22	INV	083 14	D	111 00	0

*Denotes 2nd function key

REGISTERS

00 θ	05	10	15
01 r	06	11	16
02 s	07	12	17
03 c	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 02	2	140 00	0	168 00	0	196 45	y^x
113 55	÷	141 03	3	169 01	1	197 56	*rtn
114 43	RCL	142 56	*rtn	170 65	×	198 46	*LBL
115 00	0	143 46	*LBL	171 43	RCL	199 19	*D′
116 00	0	144 18	*C′	172 00	0	200 42	STO
117 95	=	145 43	RCL	173 03	3	201 00	0
118 42	STO	146 00	0	174 55	÷	202 00	0
119 00	0	147 01	1	175 02	2	203 32	sin
120 01	1	148 65	×	176 95	=	204 80	*if pos
121 41	GTO	149 43	RCL	177 94	+/−	205 35	$\sqrt[x]{y}$
122 52	EE	150 00	0	178 85	+	206 23	lnx
123 46	*LBL	151 02	2	179 43	RCL	207 46	*LBL
124 16	*A′	152 55	÷	180 00	0	208 35	$\sqrt[x]{y}$
125 43	RCL	153 02	2	181 04	4	209 43	RCL
126 00	0	154 95	=	182 95	=	210 00	0
127 00	0	155 42	STO	183 56	*rtn	211 00	0
128 56	*rtn	156 00	0	184 46	*LBL	212 56	*rtn
129 43	RCL	157 04	4	185 10	*E′	213 00	
130 00	0	158 56	*rtn	186 42	STO	214 00	
131 01	1	159 43	RCL	187 00	0	215 00	
132 56	*rtn	160 00	0	188 01	1	216 00	
133 46	*LBL	161 00	0	189 80	*if pos	217 00	
134 17	*B′	162 55	÷	190 45	y^x	218 00	
135 43	RCL	163 02	2	191 23	lnx	219 00	
136 00	0	164 95	=	192 43	RCL	220 00	
137 02	2	165 33	cos	193 00	0	221 00	
138 56	*rtn	166 65	×	194 01	1	222 00	
139 43	RCL	167 43	RCL	195 46	*LBL	223 00	

*Denotes 2nd function key

POLYNOMIAL EVALUATION

This program evaluates a polynomial of the form:

$$y = a_0 + a_1x + a_2x^2 + a_3x^3 + \ldots + a_nx^n$$

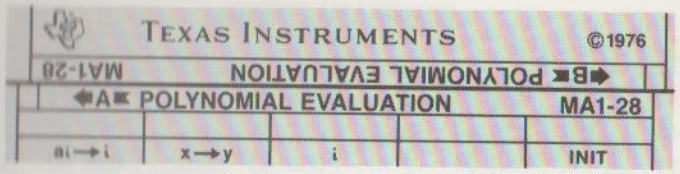
given values for a_i, $i = 0,1,2 \ldots n$, and for x. y is limited to a 13th degree polynomial ($n \leq 13$).

Example: $a_0 = 1$, $a_1 = 1$, $a_2 = 2$, $a_3 = 3$, $a_4 = 4$, $x = 2, -2$

Enter	Press	Display	Comments
	E	0.	Initialize
1	A	0.	Enter a_0, display 0
1	A	1.	Enter a_1, display 1
2	A	2.	Enter a_2, display 2
3	A	3.	Enter a_3, display 3
4	A	4.	Enter a_4, display 4
2	B	99.	Enter x_1, display y_1
2	+/− B	47.	Enter x_2, display y_2

To change a_1 from 1 to 7:

1	C	1.	i^{th} coefficient
7	A	1.	i
2	B	111.	Enter x, display y



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Initialize		E	
3	Enter a_i, $i = 1,2,3 \ldots n$	a_i	A	i
4	Enter x	x	B	y
	Repeat Step 4 for new value			
	of x			
	To change one of the			
	coefficient values, a_i:			
5	Enter the subscript i for			
	that coefficient	i	C	i
6	Enter the new a_i	a_i	A	i
	Continue with Step 4			

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 81	HLT	028 01	1	056 07	7	084 85	+
001 46	*LBL	029 44	SUM	057 85	+	085 43	RCL
002 11	A	030 01	1	058 43	RCL	086 00	0
003 42	STO	031 09	9	059 01	1	087 08	8
004 01	1	032 43	RCL	060 01	1	088 95	=
005 08	8	033 01	1	061 95	=	089 65	×
006 43	RCL	034 09	9	062 65	×	090 43	RCL
007 01	1	035 75	−	063 43	RCL	091 01	1
008 09	9	036 01	1	064 01	1	092 07	7
009 75	−	037 95	=	065 07	7	093 85	+
010 01	1	038 56	*rtn	066 85	+	094 43	RCL
011 04	4	039 46	*LBL	067 43	RCL	095 00	0
012 95	=	040 12	B	068 01	1	096 07	7
013 22	INV	041 42	STO	069 00	0	097 95	=
014 80	*if pos	042 01	1	070 95	=	098 65	×
015 45	y^x	043 07	7	071 65	×	099 43	RCL
016 00	0	044 65	×	072 43	RCL	100 01	1
017 20	*1/x	045 43	RCL	073 01	1	101 07	7
018 86	*rset	046 01	1	074 07	7	102 85	+
019 46	*LBL	047 03	3	075 85	+	103 43	RCL
020 45	y^x	048 85	+	076 43	RCL	104 00	0
021 43	RCL	049 43	RCL	077 00	0	105 06	6
022 01	1	050 01	1	078 09	9	106 95	=
023 08	8	051 02	2	079 95	=	107 65	×
024 36	*IND	052 95	=	080 65	×	108 43	RCL
025 42	STO	053 65	×	081 43	RCL	109 01	1
026 01	1	054 43	RCL	082 01	1	110 07	7
027 09	9	055 01	1	083 07	7	111 85	+

*Denotes 2nd function key

REGISTERS

00 a_0	05 a_5	10 a_{10}	15
01 a_1	06 a_6	11 a_{11}	16
02 a_2	07 a_7	12 a_{12}	17 x
03 a_3	08 a_8	13 a_{13}	18 Used
04 a_4	09 a_9	14	19 Used

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 43	RCL	140 00	0	168 46	*LBL	196 00	
113 00	0	141 02	2	169 13	C	197 00	
114 05	5	142 95	=	170 40	*x^2	198 00	
115 95	=	143 65	×	171 30	*$\sqrt{x}$	199 00	
116 65	×	144 43	RCL	172 42	STO	200 00	
117 43	RCL	145 01	1	173 01	1	201 00	
118 01	1	146 07	7	174 09	9	202 00	
119 07	7	147 85	+	175 56	*rtn	203 00	
120 85	+	148 43	RCL	176 00		204 00	
121 43	RCL	149 00	0	177 00		205 00	
122 00	0	150 01	1	178 00		206 00	
123 04	4	151 95	=	179 00		207 00	
124 95	=	152 65	×	180 00		208 00	
125 65	×	153 43	RCL	181 00		209 00	
126 43	RCL	154 01	1	182 00		210 00	
127 01	1	155 07	7	183 00		211 00	
128 07	7	156 95	=	184 00		212 00	
129 85	+	157 85	+	185 00		213 00	
130 43	RCL	158 43	RCL	186 00		214 00	
131 00	0	159 00	0	187 00		215 00	
132 03	3	160 00	0	188 00		216 00	
133 95	=	161 95	=	189 00		217 00	
134 65	×	162 56	*rtn	190 00		218 00	
135 43	RCL	163 46	*LBL	191 00		219 00	
136 01	1	164 15	E	192 00		220 00	
137 07	7	165 25	CLR	193 00		221 00	
138 85	+	166 47	*CMs	194 00		222 00	
139 43	RCL	167 86	*rset	195 00		223 00	

*Denotes 2nd function key

COMPLEX ARITHMETIC

Given two complex numbers in the form a + bi and c + di, this program, with a, b, c, and d as inputs, calculates the following:

$$(a + bi) + (c + di) = a_1 + b_1 i$$
$$(a + bi) - (c + di) = a_2 + b_2 i$$
$$(a + bi)(c + di) = a_3 + b_3 i$$
$$(a + bi) \div (c + di) = a_4 + b_4 i$$

Where: $a_1 = a + c$ $\quad b_1 = b + d$

$a_2 = a - c$ $\quad b_2 = b - d$

$a_3 = ac - bd$ $\quad b_3 = ad + bc$

$a_4 = (ac + bd)/(c^2 + d^2)$ $\quad b_4 = (bc - ad)/(c^2 + d^2)$

After entering a, b, c, and d by pressing [A], [2nd] [A'], [B], and [2nd] [B'] respectively, a_1 and b_1, a_2 and b_2, a_3 and b_3, a_4 and b_4 are calculated as follows:

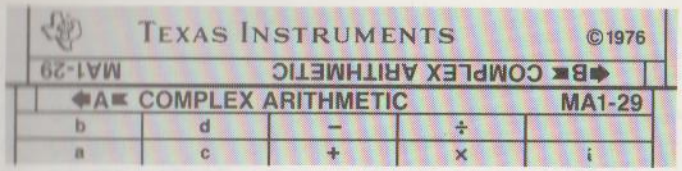
{ [C] ⇒ a_1 ; [E] ⇒ b_1 } { [D] ⇒ a_3 ; [E] ⇒ b_3 }

{ [2nd] [C'] ⇒ a_2 ; [E] ⇒ b_2 } { [2nd] [D'] ⇒ a_4 ; [E] ⇒ b_4 }

These pairs of operations may be performed in any order. After any of the above operations, the original input can be replaced with the results by pressing either [A] or [B] to enter the real part then [E] [2nd] [A'] or [E] [2nd] [B'] to enter the corresponding imaginary part.

The following example illustrates the arithmetic operations for the two complex numbers: (2 + 3i) and (4 − 5i).

Enter	Press	Display	Comments
2	[A]	2.	a
3	[2nd] [A']	3.	b
4	[B]	4.	c
5	[+/−] [2nd] [B']	−5.	d
	[C]	6.	a_1
	[E]	−2.	b_1
	[2nd] [C']	−2.	a_2
	[E]	8.	b_2
	[D]	23.	a_3
	[E]	2.	b_3
	[2nd] [D']	−.1707317073	a_4
	[E]	.5365853659	b_4



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2		a	[A]	a
3		b	[2nd] [A']	b
4		c	[B]	c
5		d	[2nd] [B']	d
6	Addition		[C]	a_1
7	To obtain b_1 after			
	any operation *		[E]	b_1
8	Subtraction		[2nd] [C']	a_2
9	Multiplication		[D]	a_3
10	Division		[2nd] [D']	a_4
	Steps 2-5 may be			
	replaced by			
2		a	[A]	a
3		b	[RUN]	b
4		c	[RUN]	c
5		d	[RUN]	d

* [E] must directly follow [C], [2nd] [C'], [D] or [2nd] [D'] to obtain the imaginary part corresponding to that operation.

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 05	5	056 43	RCL	084 43	RCL
001 11	A	029 56	*rtn	057 00	0	085 00	0
002 42	STO	030 46	*LBL	058 04	4	086 02	2
003 00	0	031 13	C	059 95	=	087 95	=
004 01	1	032 43	RCL	060 15	E	088 15	E
005 56	*rtn	033 00	0	061 43	RCL	089 43	RCL
006 46	*LBL	034 02	2	062 00	0	090 00	0
007 16	*A'	035 85	+	063 01	1	091 01	1
008 42	STO	036 43	RCL	064 75	−	092 65	X
009 00	0	037 00	0	065 43	RCL	093 43	RCL
010 02	2	038 04	4	066 00	0	094 00	0
011 56	*rtn	039 95	=	067 03	3	095 03	3
012 46	*LBL	040 15	E	068 95	=	096 75	−
013 12	B	041 43	RCL	069 56	*rtn	097 43	RCL
014 42	STO	042 00	0	070 46	*LBL	098 00	0
015 00	0	043 01	1	071 14	D	099 02	2
016 03	3	044 85	+	072 43	RCL	100 65	X
017 56	*rtn	045 43	RCL	073 00	0	101 43	RCL
018 46	*LBL	046 00	0	074 01	1	102 00	0
019 17	*B'	047 03	3	075 65	X	103 04	4
020 42	STO	048 95	=	076 43	RCL	104 95	=
021 00	0	049 56	*rtn	077 00	0	105 56	*rtn
022 04	4	050 46	*LBL	078 04	4	106 46	*LBL
023 56	*rtn	051 18	*C'	079 85	+	107 19	*D'
024 46	*LBL	052 43	RCL	080 43	RCL	108 43	RCL
025 15	E	053 00	0	081 00	0	109 00	0
026 48	*EXC	054 02	2	082 03	3	110 03	3
027 00	0	055 75	−	083 65	X	111 65	X

*Denotes 2nd function key

REGISTERS

00	05 Used	10	15
01 a	06 Used	11	16
02 b	07	12	17
03 c	08	13	18
04 d	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 43	RCL	140 43	RCL	168 06	6	196 00	
113 00	0	141 00	0	169 56	*rtn	197 00	
114 02	2	142 04	4	170 00		198 00	
115 75	−	143 95	=	171 00		199 00	
116 43	RCL	144 55	÷	172 00		200 00	
117 00	0	145 43	RCL	173 00		201 00	
118 01	1	146 00	0	174 00		202 00	
119 65	X	147 06	6	175 00		203 00	
120 43	RCL	148 95	=	176 00		204 00	
121 00	0	149 56	*rtn	177 00		205 00	
122 04	4	150 46	*LBL	178 00		206 00	
123 95	=	151 10	*E'	179 00		207 00	
124 55	÷	152 43	RCL	180 00		208 00	
125 10	*E'	153 00	0	181 00		209 00	
126 95	=	154 03	3	182 00		210 00	
127 15	E	155 40	x^2	183 00		211 00	
128 43	RCL	156 42	STO	184 00		212 00	
129 00	0	157 00	0	185 00		213 00	
130 01	1	158 06	6	186 00		214 00	
131 65	X	159 43	RCL	187 00		215 00	
132 43	RCL	160 00	0	188 00		216 00	
133 00	0	161 04	4	189 00		217 00	
134 03	3	162 40	*x^2	190 00		218 00	
135 85	+	163 44	SUM	191 00		219 00	
136 43	RCL	164 00	0	192 00		220 00	
137 00	0	165 06	6	193 00		221 00	
138 02	2	166 43	RCL	194 00		222 00	
139 65	X	167 00	0	195 00		223 00	

*Denotes 2nd function key

COMPLEX FUNCTIONS (1)

This program computes the following for $z = a + bi$.

$$|z| = \sqrt{a^2 + b^2} = r,\ \theta = \tan^{-1}(b/a)$$

$$z^2 = r^2 \exp(i2\theta)$$

$$\sqrt{z} = \sqrt{r} \exp\left(i\frac{\theta}{2}\right)$$

$$1/z = 1/r \exp(-i\theta)$$

$$z^n = r^n \exp(in\theta)$$

$$z^{1/n} = r^{1/n} \exp\left(i\,\frac{\theta + 2\pi k}{n}\right) = r^{1/n} \exp\left(i\,\frac{\theta + 360\ k}{n}\right)$$

where: k = 0, 1, 2, ..., n − 1
a ≠ 0
z ≠ 0
n ≠ 0
r = polar coordinate radius
θ = polar coordinate angle
exp = base of Naperian system, e

More operations on complex functions are available in MA1-31, 32.

Reference: *Complex Variables and Applications,* R. V. Churchill, McGraw-Hill, 1960.

Angle = radians

Example: Evaluate |−3 + 12i|

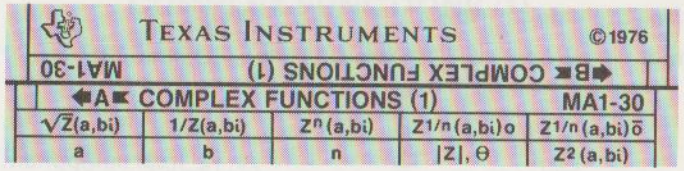
Enter	Press	Display	Comments
3	[+/−] [A]	−3.	a
12	[B]	12.	b
	[D]	12.36931688	|z|
	[RUN]	1.81577499	θ

Example: Evaluate $(4 + 2i)^2$

Enter	Press	Display	Comments
4	[A]	4.	a
2	[B]	2.	b
	[E]	12.	z^2 (real component)
	[RUN]	16.	z^2 (imag. component)

Example: Evaluate $(4 + 5i)^{1/3}$

Enter	Press	Display	Comments
4	[A]	4.	a
5	[B]	5.	b
3	[C]	3.	n
	[2nd] [D']	1.774720263	real component, root 1
	[RUN]	.5464295259	imag. component, root 1
	[2nd] [E']	−1.360581983	real component, root 2
	[RUN]	1.26373807	imag. component, root 2
	[2nd] [F']	−.4141382809	real component, root 3
	[RUN]	−1.810167596	imag. component, root 3



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Set D/R switch to R					
3	Enter a	a	A			a
4	Enter b	b	B			b
5*	Enter n	n	C			n
6	Compute |z|, given a,b		D			|z|
7			RUN			θ
8	Compute z^2, given a,b		E			z^2 (real)
9			RUN			z^2 (imag)
10	Compute $\sqrt{z}$, given a,b		2nd	A'		$\sqrt{z}$ (real)
11			RUN			$\sqrt{z}$ (imag)
12	Compute 1/z, given a,b		2nd	B'		1/z (real)
13			RUN			1/z (imag)
14	Compute Z^n, given a,b,n		2nd	C'		z^n (real)
15			RUN			z^n (imag)
16	Compute $z^{1/n}$, given a,b,n		2nd	D'		$z^{1/n}$ (real) k = 0
17			RUN			$z^{1/n}$ (imag) k = 0
18	Perform 18, 19 for					
	k = 1,2,...,n−1		2nd	E'		$z^{1/n}$ (real) k ≠ 0
19			RUN			$z^{1/n}$ (imag) k ≠ 0

*NOTE: It is not necessary to enter n for Steps 6-13

MA1-30

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 00	0	056 41	GTO	084 14	D
001 11	A	029 00	0	057 85	+	085 45	y^x
002 42	STO	030 43	RCL	058 46	*LBL	086 43	RCL
003 00	0	031 00	0	059 16	*A′	087 00	0
004 01	1	032 02	2	060 14	D	088 03	3
005 56	*rtn	033 22	INV	061 30	*$\sqrt{x}$	089 95	=
006 46	*LBL	034 39	*P/R	062 48	*EXC	090 48	*EXC
007 12	B	035 46	*LBL	063 00	0	091 00	0
008 42	STO	036 85	+	064 00	0	092 00	0
009 00	0	037 48	*EXC	065 55	÷	093 65	×
010 02	2	038 00	0	066 02	2	094 43	RCL
011 56	*rtn	039 00	0	067 95	=	095 00	0
012 46	*LBL	040 56	*rtn	068 39	*P/R	096 03	3
013 13	C	041 43	RCL	069 41	GTO	097 95	=
014 42	STO	042 00	0	070 85	+	098 39	*P/R
015 00	0	043 00	0	071 46	*LBL	099 41	GTO
016 03	3	044 56	*rtn	072 17	*B′	100 85	+
017 20	*1/x	045 46	*LBL	073 14	D	101 46	*LBL
018 43	RCL	046 15	E	074 20	*1/x	102 19	*D′
019 00	0	047 14	D	075 48	*EXC	103 00	0
020 03	3	048 40	*x^2	076 00	0	104 42	STO
021 56	*rtn	049 48	*EXC	077 00	0	105 00	0
022 46	*LBL	050 00	0	078 94	+/−	106 06	6
023 14	D	051 00	0	079 39	*P/R	107 14	D
024 43	RCL	052 65	×	080 41	GTO	108 35	*$\sqrt[x]{y}$
025 00	0	053 02	2	081 85	+	109 43	RCL
026 01	1	054 95	=	082 46	*LBL	110 00	0
027 42	STO	055 39	*P/R	083 18	*C′	111 03	3

*Denotes 2nd function key

REGISTERS

00 Used	05 Used	10	15
01 a	06 Used	11	16
02 b	07 Used	12	17
03 n	08	13	18
04 Used	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 95	=	140 03	3	168 46	*LBL	196 00	
113 42	STO	141 95	=	169 33	cos	197 00	
114 00	0	142 42	STO	170 03	3	198 00	
115 04	4	143 00	0	171 06	6	199 00	
116 43	RCL	144 07	7	172 00	0	200 00	
117 00	0	145 46	*LBL	173 41	GTO	201 00	
118 00	0	146 32	sin	174 65	×	202 00	
119 55	÷	147 43	RCL	175 46	*LBL	203 00	
120 43	RCL	148 00	0	176 10	*E′	204 00	
121 00	0	149 04	4	177 01	1	205 00	
122 03	3	150 42	STO	178 44	SUM	206 00	
123 95	=	151 00	0	179 00	0	207 00	
124 42	STO	152 00	0	180 06	6	208 00	
125 00	0	153 43	RCL	181 41	GTO	209 00	
126 05	5	154 00	0	182 32	sin	210 00	
127 09	9	155 06	6	183 00		211 00	
128 00	0	156 65	×	184 00		212 00	
129 33	cos	157 43	RCL	185 00		213 00	
130 90	*if zro	158 00	0	186 00		214 00	
131 33	cos	159 07	7	187 00		215 00	
132 02	2	160 85	+	188 00		216 00	
133 65	×	161 43	RCL	189 00		217 00	
134 59	*Π	162 00	0	190 00		218 00	
135 46	*LBL	163 05	5	191 00		219 00	
136 65	×	164 95	=	192 00		220 00	
137 55	÷	165 39	*P/R	193 00		221 00	
138 43	RCL	166 41	GTO	194 00		222 00	
139 00	0	167 85	+	195 00		223 00	

*Denotes 2nd function key

COMPLEX FUNCTIONS (2)

This program computes the following for z = a + bi.

$$e^z = e^a(\cos b + i \sin b)$$
$$\ln z = \ln |z| + i\theta,\ z \neq 0$$
$$y^z = \exp(z \ln y),\ y > 0$$
$$\log_c z = \ln z / \ln c,\ c > 0,\ z \neq 0$$

More operations on complex functions are available in MA1-30, 32

Reference: *Complex Variables and Applications*, R. V. Churchill, McGraw-Hill, 1960.

Angle = radians

Example: Evaluate $e^{(4-i)}$

Enter	Press	Display	Comments
4	A	4.	a
1	+/− RUN	−1.	b
	2nd A'	29.49950636	e^z (real)
	RUN	−45.94275908	e^z (imaginary)

Example: Evaluate ln(5 + 6i)

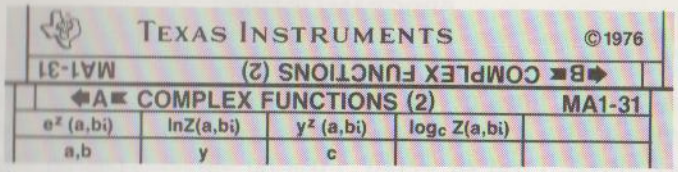
Enter	Press	Display	Comments
5	A	5.	a
6	RUN	6.	b
	2nd B'	2.055436932	ln z (real)
	RUN	.8760580506	ln z (imaginary)

Example: Evaluate $3^{(2-i)}$

Enter	Press	Display	Comments
2	A	2.	a
1	+/− RUN	−1.	b
3	B	3.	y
	2nd C'	4.093491805	y^z (real)
	RUN	−8.015193375	y^z (imag)

Example: Evaluate $\log_2(3 + 5i)$

Enter	Press	Display	Comments
3	A	3.	a
5	RUN	5.	b
2	C	2.	c
	2nd D'	2.543731421	$\log_c z$ (real)
	RUN	1.486519538	$\log_c z$ (imag)



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Enter Program (A and B)			
2	Set D/R switch to R			
3	Enter a	a	A	a
4	Enter b	b	RUN	b
5	Enter y			
	(for Steps 11-12 only)	y	B	y
6	Enter c			
	(for Steps 13-14 only)	c	C	c
7	Calculate e^z, given a,b		2nd A'	e^z (real)
8			RUN	e^z (imag)
9	Calculate ln z, given a,b		2nd B'	ln z (real)
10			RUN	ln z (imag)
11	Calculate y^z, given a,b,y		2nd C'	y^z (real)
12			RUN	y^z (imag)
13	Calculate $\log_c z$, given a,b,c		2nd D'	$\log_c z$ (real)
14			RUN	$\log_c z$ (imag)

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 04	4	056 01	1	084 18	*C'
001 11	A	029 56	*rtn	057 42	STO	085 43	RCL
002 42	STO	030 46	*LBL	058 00	0	086 00	0
003 00	0	031 16	*A'	059 00	0	087 01	1
004 01	1	032 43	RCL	060 43	RCL	088 65	×
005 56	*rtn	033 00	0	061 00	0	089 43	RCL
006 42	STO	034 02	2	062 02	2	090 00	0
007 00	0	035 33	cos	063 22	INV	091 03	3
008 02	2	036 46	*LBL	064 39	*P/R	092 95	=
009 56	*rtn	037 65	×	065 48	*EXC	093 22	INV
010 46	*LBL	038 65	×	066 00	0	094 23	Inx
011 12	B	039 43	RCL	067 00	0	095 42	STO
012 42	STO	040 00	0	068 90	*if zro	096 00	0
013 00	0	041 01	1	069 52	EE	097 05	5
014 03	3	042 22	INV	070 23	Inx	098 43	RCL
015 23	Inx	043 23	Inx	071 42	STO	099 00	0
016 48	*EXC	044 95	=	072 00	0	100 02	2
017 00	0	045 56	*rtn	073 05	5	101 65	×
018 03	3	046 43	RCL	074 25	CLR	102 43	RCL
019 56	*rtn	047 00	0	075 43	RCL	103 00	0
020 46	*LBL	048 02	2	076 00	0	104 03	3
021 13	C	049 32	sin	077 05	5	105 95	=
022 42	STO	050 41	GTO	078 56	*rtn	106 33	cos
023 00	0	051 65	×	079 43	RCL	107 46	*LBL
024 04	4	052 46	*LBL	080 00	0	108 85	+
025 23	Inx	053 17	*B'	081 00	0	109 65	×
026 48	*EXC	054 43	RCL	082 56	*rtn	110 43	RCL
027 00	0	055 00	0	083 46	*LBL	111 00	0

*Denotes 2nd function key

REGISTERS

00 Used	05 Used	10	15
01 a	06	11	16
02 b	07	12	17
03 y	08	13	18
04 c	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 05	5	140 55	÷	168 00		196 00	
113 95	=	141 43	RCL	169 00		197 00	
114 56	*rtn	142 00	0	170 00		198 00	
115 43	RCL	143 04	4	171 00		199 00	
116 00	0	144 95	=	172 00		200 00	
117 02	2	145 56	*rtn	173 00		201 00	
118 65	×	146 46	*LBL	174 00		202 00	
119 43	RCL	147 52	EE	175 00		203 00	
120 00	0	148 20	*1/x	176 00		204 00	
121 03	3	149 00	0	177 00		205 00	
122 95	=	150 56	*rtn	178 00		206 00	
123 32	sin	151 00		179 00		207 00	
124 41	GTO	152 00		180 00		208 00	
125 85	+	153 00		181 00		209 00	
126 46	*LBL	154 00		182 00		210 00	
127 19	*D'	155 00		183 00		211 00	
128 17	*B'	156 00		184 00		212 00	
129 90	*if zro	157 00		185 00		213 00	
130 52	EE	158 00		186 00		214 00	
131 55	÷	159 00		187 00		215 00	
132 43	RCL	160 00		188 00		216 00	
133 00	0	161 00		189 00		217 00	
134 04	4	162 00		190 00		218 00	
135 95	=	163 00		191 00		219 00	
136 56	*rtn	164 00		192 00		220 00	
137 43	RCL	165 00		193 00		221 00	
138 00	0	166 00		194 00		222 00	
139 00	0	167 00		195 00		223 00	

*Denotes 2nd function key

COMPLEX FUNCTIONS (3)

This program computes the following when z and w have the form a + bi.

$$z^w = \exp(w \ln z)$$

$$z^{1/w} = \exp\left(\frac{\ln z}{w}\right)$$

$$\log_z w = \frac{\ln w}{\ln z}$$

More operations on complex functions are available in MA1-30, 31.

NOTE: If the real part of z or w is 1, entering 0 for the imaginary part of the same number results in a flashing 0.

Reference: *Complex Variables and Applications*, R. V. Churchill, McGraw-Hill, 1960.

Angle = radians

Example: Evaluate $(3 + i)^{(1+2i)}$

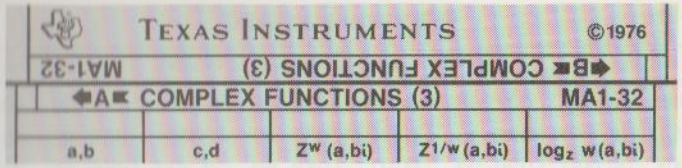
Enter	Press	Display	Comments
3	A	3.	a
1	RUN	1.	b
1	B	1.	c
2	RUN	2.	d
	C	−1.444242665	z^w (real)
	RUN	.8216662074	z^w (imag)

Example: Evaluate $(2 - i)^{\left(\frac{1}{1+i}\right)}$

Enter	Press	Display	Comments
2	A	2.	a
1	+/− RUN	−1.	b
1	B	1.	c
1	RUN	1.	d
	D	.9553409139	$z^{1/w}$ (real)
	RUN	−.7026929073	$z^{1/w}$ (imag)

Example: Evaluate $\log_{(2-i)}(1 + 2i)$

Enter	Press	Display	Comments
2	A	2.	a
1	+/− RUN	−1.	b
1	B	1.	c
2	RUN	2.	d
	E	.1556397124	$\log_z w$ (real)
	RUN	1.465493871	$\log_z w$ (imag)



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	Set D/R switch to R					
3	Enter a	a	A			a
4	Enter b	b	RUN			b
5	Enter c	c	B			c
6	Enter d	d	RUN			d
7	Calculate z^w, given a,b,c,d		C			z^w, (real)
8			RUN			z^w, (imag)
9	Calculate $z^{1/w}$, given a,b,c,d		D			$z^{1/w}$ (real)
10			RUN			$z^{1/w}$ (imag)
11	Calculate $\log_z w$, given					
	a,b,c,d		E			$\log_z w$ (real)
12			RUN			$\log_z w$ (imag)

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 46	*LBL	056 16	*A′	084 00	0
001 11	A	029 16	*A′	057 42	STO	085 05	5
002 42	STO	030 22	INV	058 00	0	086 85	+
003 00	0	031 39	*P/R	059 06	6	087 43	RCL
004 00	0	032 48	*EXC	060 43	RCL	088 00	0
005 56	*rtn	033 00	0	061 00	0	089 03	3
006 42	STO	034 00	0	062 00	0	090 95	=
007 00	0	035 56	*rtn	063 42	STO	091 46	*LBL
008 08	8	036 46	*LBL	064 00	0	092 91	RUN
009 16	*A′	037 12	B	065 07	7	093 39	*P/R
010 23	lnx	038 42	STO	066 43	RCL	094 42	STO
011 48	*EXC	039 00	0	067 00	0	095 00	0
012 00	0	040 00	0	068 08	8	096 01	1
013 00	0	041 56	*rtn	069 56	*rtn	097 33	cos
014 16	*A′	042 42	STO	070 46	*LBL	098 46	*LBL
015 42	STO	043 00	0	071 13	C	099 65	×
016 00	0	044 08	8	072 43	RCL	100 65	×
017 02	2	045 16	*A′	073 00	0	101 43	RCL
018 43	RCL	046 42	STO	074 04	4	102 00	0
019 00	0	047 00	0	075 65	×	103 00	0
020 00	0	048 04	4	076 43	RCL	104 22	INV
021 42	STO	049 23	lnx	077 00	0	105 23	lnx
022 00	0	050 48	*EXC	078 02	2	106 95	=
023 03	3	051 00	0	079 95	=	107 56	*rtn
024 43	RCL	052 00	0	080 42	STO	108 43	RCL
025 00	0	053 42	STO	081 00	0	109 00	0
026 08	8	054 00	0	082 00	0	110 01	1
027 56	*rtn	055 05	5	083 43	RCL	111 32	sin

*Denotes 2nd function key

REGISTERS

00 Used	05 θ_w	10	15
01 Used	06 r_w'	11	16
02 r_z'	07 θ_w'	12	17
03 θ_z'	08 Used	13	18
04 r_w	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 41	GTO	140 00	0	168 00		196 00	
113 65	×	141 06	6	169 00		197 00	
114 46	*LBL	142 55	÷	170 00		198 00	
115 14	D	143 43	RCL	171 00		199 00	
116 43	RCL	144 00	0	172 00		200 00	
117 00	0	145 02	2	173 00		201 00	
118 02	2	146 95	=	174 00		202 00	
119 55	÷	147 42	STO	175 00		203 00	
120 43	RCL	148 00	0	176 00		204 00	
121 00	0	149 00	0	177 00		205 00	
122 04	4	150 43	RCL	178 00		206 00	
123 95	=	151 00	0	179 00		207 00	
124 42	STO	152 07	7	180 00		208 00	
125 00	0	153 75	−	181 00		209 00	
126 00	0	154 43	RCL	182 00		210 00	
127 43	RCL	155 00	0	183 00		211 00	
128 00	0	156 03	3	184 00		212 00	
129 03	3	157 95	=	185 00		213 00	
130 75	−	158 39	*P/R	186 00		214 00	
131 43	RCL	159 48	*EXC	187 00		215 00	
132 00	0	160 00	0	188 00		216 00	
133 05	5	161 00	0	189 00		217 00	
134 95	=	162 56	*rtn	190 00		218 00	
135 41	GTO	163 48	*EXC	191 00		219 00	
136 91	RUN	164 00	0	192 00		220 00	
137 46	*LBL	165 00	0	193 00		221 00	
138 15	E	166 56	*rtn	194 00		222 00	
139 43	RCL	167 00	0	195 00		223 00	

*Denotes 2nd function key

CONVERSIONS (1)

This program provides length conversions by pressing the user defined keys as follows:

- [A] inches to centimeters (2.54)
- [B] feet to meters (.3048)
- [C] yards to meters (.9144)
- [D] miles to kilometers (1.609344)
- [E] miles to nautical miles (.86897624)

Inverses of these conversions are obtained with the second function of the above user defined keys. Area and volume conversions may be obtained by pressing the conversion key twice or three times, respectively.

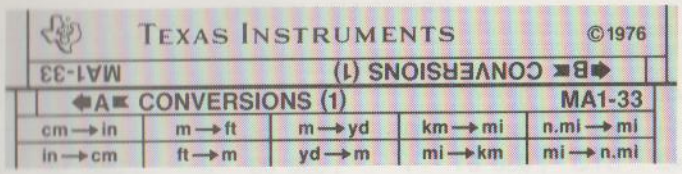
NOTE: These conversions can be accomplished without affecting a mathematical calculation that is in progress; however, memory register 00 (R_{00}) must be reserved for conversions.

Example: Convert 3.5 inches to the equivalent number of centimeters.

Enter	Press	Display
3.5	[A]	8.89

Find the volume in cubic centimeters of a rectangular tank 14 inches by 12.6 inches by 4.2 inches.

Enter	Press	Display	Comments
14	[×]	14.	
12.6	[×]	176.4	
4.2	[=]	740.88	Volume in cubic inches
	[A] [A] [A]	12140.84798	Volume in cubic centimeters



USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A only)					
2	To convert:					
	inches to centimeters	inches	[A]			centimeters
	feet to meters	feet	[B]			meters
	yards to meters	yards	[C]			meters
	miles to kilometers	miles	[D]			kilometers
	miles to nautical miles	miles	[E]			n. miles
3	To convert:					
	centimeters to inches	centimeters	[2nd]	[A']		inches
	meters to feet	meters	[2nd]	[B']		feet
	meters to yards	meters	[2nd]	[C']		yards
	kilometers to miles	kilometers	[2nd]	[D']		miles
	nautical miles to miles	n. miles	[2nd]	[E']		miles

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 93	•	056 08	8	084 56	*rtn
001 11	A	029 09	9	057 06	6	085 46	*LBL
002 42	STO	030 01	1	058 08	8	086 18	*C′
003 00	0	031 04	4	059 09	9	087 20	*1/x
004 00	0	032 04	4	060 07	7	088 13	C
005 02	2	033 41	GTO	061 06	6	089 20	*1/x
006 93	•	034 87	*1′	062 02	2	090 56	*rtn
007 05	5	035 46	*LBL	063 04	4	091 46	*LBL
008 04	4	036 14	D	064 46	*LBL	092 19	*D′
009 41	GTO	037 42	STO	065 87	*1′	093 20	*1/x
010 87	*1′	038 00	0	066 49	*PROD	094 14	D
011 46	*LBL	039 00	0	067 00	0	095 20	*1/x
012 12	B	040 01	1	068 00	0	096 56	*rtn
013 42	STO	041 93	•	069 43	RCL	097 46	*LBL
014 00	0	042 06	6	070 00	0	098 10	*E′
015 00	0	043 00	0	071 00	0	099 20	*1/x
016 93	•	044 09	9	072 56	*rtn	100 15	E
017 03	3	045 03	3	073 46	*LBL	101 20	*1/x
018 00	0	046 04	4	074 16	*A′	102 56	*rtn
019 04	4	047 04	4	075 20	*1/x	103 00	
020 08	8	048 41	GTO	076 11	A	104 00	
021 41	GTO	049 87	*1′	077 20	*1/x	105 00	
022 87	*1′	050 46	*LBL	078 56	*rtn	106 00	
023 46	*LBL	051 15	E	079 46	*LBL	107 00	
024 13	C	052 42	STO	080 17	*B′	108 00	
025 42	STO	053 00	0	081 20	*1/x	109 00	
026 00	0	054 00	0	082 12	B	110 00	
027 00	0	055 93	•	083 20	*1/x	111 00	

*Denotes 2nd function key

REGISTERS

00 Used	05	10	15
01	06	11	16
02	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1	2	3	4

CONVERSIONS (2)

This program provides volume, weight, and temperature conversions by pressing the user defined keys as follows:

- [A] °F to °C (Fahrenheit to Celsius) $C = \frac{5}{9}(F - 32)$
- [B] fluid ounces to liters (.0295735296)
- [C] gallons to liters (3.785411784)
- [D] ounces to grams (28.34952313)
- [E] pounds to kilograms (.45359237)

Inverses of these conversions are obtained with the second function of the above user defined keys.

NOTE: These conversions can be accomplished without affecting a mathematical calculation that is in progress; however,memory register 00 (R_{00}) must be reserved for conversions.

Example: Convert 410°F to °C.

Enter	Press	Display	Comments
410	[A]	210.	$\frac{5}{9}(F - 32)$

Convert 25 gallons to liters.

Enter	Press	Display
25	[C]	94.6352946

Convert 125 pounds to kilograms.

Enter	Press	Display
125	[E]	56.69904625

Convert 6.2 pounds per gallon to kilograms per liter.

Enter	Press	Display	Comments
6.2	[E]	2.812272694	kilograms per gallon
	[2nd] [C']	.7429238494	kilograms per liter

TEXAS INSTRUMENTS ©1976

MA1-34 (2) SNOISREVNOC ➡B⬅

⬅A➡ CONVERSIONS (2) MA1-34

°C→°F	lit→fl oz	lit→gal	g→oz	kg→lb
°F→°C	fl oz→lit	gal→lit	oz→g	lb→kg

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Enter Program (A and B)					
2	To convert:					
	°F to °C	°F	[A]			°C
	fluid oz. to liters	fl. oz.	[B]			liters
	gallons to liters	gallons	[C]			liters
	ounces to grams	ounces	[D]			grams
	pounds to kilograms	pounds	[E]			kilograms
3	To convert:					
	°C to °F	°C	[2nd]	[A']		°F
	liters to fluid oz.	liters	[2nd]	[B']		fl. oz.
	liters to gallons	liters	[2nd]	[C']		gallons
	grams to ounces	grams	[2nd]	[D']		ounces
	kilograms to pounds	kilograms	[2nd]	[E']		pounds

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
000 46	*LBL	028 42	STO	056 05	5	084 00	0
001 11	A	029 00	0	057 02	2	085 02	2
002 42	STO	030 00	0	058 09	9	086 08	8
003 00	0	031 01	1	059 06	6	087 93	•
004 00	0	032 93	•	060 41	GTO	088 03	3
005 03	3	033 08	8	061 87	*1′	089 04	4
006 02	2	034 49	*PROD	062 46	*LBL	090 09	9
007 94	+/−	035 00	0	063 13	C	091 05	5
008 44	SUM	036 00	0	064 42	STO	092 02	2
009 00	0	037 03	3	065 00	0	093 03	3
010 00	0	038 02	2	066 00	0	094 01	1
011 01	1	039 44	SUM	067 03	3	095 03	3
012 93	•	040 00	0	068 93	•	096 41	GTO
013 08	8	041 00	0	069 07	7	097 87	*1′
014 20	*1/x	042 41	GTO	070 08	8	098 46	*LBL
015 46	*LBL	043 88	*2′	071 05	5	099 15	E
016 87	*1′	044 46	*LBL	072 04	4	100 42	STO
017 49	*PROD	045 12	B	073 01	1	101 00	0
018 00	0	046 42	STO	074 01	1	102 00	0
019 00	0	047 00	0	075 07	7	103 93	•
020 46	*LBL	048 00	0	076 08	8	104 04	4
021 88	*2′	049 93	•	077 04	4	105 05	5
022 43	RCL	050 00	0	078 41	GTO	106 03	3
023 00	0	051 02	2	079 87	*1′	107 05	5
024 00	0	052 09	9	080 46	*LBL	108 09	9
025 56	*rtn	053 05	5	081 14	D	109 02	2
026 46	*LBL	054 07	7	082 42	STO	110 03	3
027 16	*A′	055 03	3	083 00	0	111 07	7

*Denotes 2nd function key

REGISTERS

00 Used	05	10	15
01	06	11	16
02	07	12	17
03	08	13	18
04	09	14	19

FLAGS

0	1	2	3	4

PROGRAM LISTING

DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY	DISPLAY	KEY
112 41	GTO	140 00		168 00		196 00	
113 87	*1′	141 00		169 00		197 00	
114 46	*LBL	142 00		170 00		198 00	
115 17	*B′	143 00		171 00		199 00	
116 20	*1/x	144 00		172 00		200 00	
117 12	B	145 00		173 00		201 00	
118 20	*1/x	146 00		174 00		202 00	
119 56	*rtn	147 00		175 00		203 00	
120 46	*LBL	148 00		176 00		204 00	
121 18	*C′	149 00		177 00		205 00	
122 20	*1/x	150 00		178 00		206 00	
123 13	C	151 00		179 00		207 00	
124 20	*1/x	152 00		180 00		208 00	
125 56	*rtn	153 00		181 00		209 00	
126 46	*LBL	154 00		182 00		210 00	
127 19	*D′	155 00		183 00		211 00	
128 20	*1/x	156 00		184 00		212 00	
129 14	D	157 00		185 00		213 00	
130 20	*1/x	158 00		186 00		214 00	
131 56	*rtn	159 00		187 00		215 00	
132 46	*LBL	160 00		188 00		216 00	
133 10	*E′	161 00		189 00		217 00	
134 20	*1/x	162 00		190 00		218 00	
135 15	E	163 00		191 00		219 00	
136 20	*1/x	164 00		192 00		220 00	
137 56	*rtn	165 00		193 00		221 00	
138 00		166 00		194 00		222 00	
139 00		167 00		195 00		223 00	

*Denotes 2nd function key